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Lexical access in brain-damaged individuals: Evidence from anomic aphasia

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Abstract: Facilitation and inhibition are the two mechanisms of lexical activation. If one word in the lexical facilitates the activation of the other word, it is termed facilitation. On the other hand, if one word/lexical item impedes the activation of the other word in the lexicon, it is called inhibition. Many experimental tasks like naming and priming tasks can be used to tap these two mechanisms of lexical activation. The current study aimed to test these two patterns of lexical activation in persons with anomic aphasia. Ten persons with anomic aphasia and ten neurologically healthy individuals designated as group 1 and group 2 served as participants. The blocked naming task was administered to the participants. The semantically related blocks comprised pictures belonging to the same lexical category, while semantically unrelated blocks comprised pictures belonging to different lexical categories. For group 1, vocal reaction time and accuracy scores were better for unrelated blocks than related ones. For group 2, there was no evident difference between the vocal reaction time and accuracy scores for related and unrelated blocks. The difference between the vocal reaction time for semantically related and unrelated blocks was significant statistically only for group 1, indicating that the mechanism of lexical activation was different for the two groups. Better vocal reaction time for unrelated blocks indicated inhibition in persons with anomic aphasia.

Keywords: Facilitation; Inhibition; Vocal reaction time; Accuracy;

1.0 INTRODUCTION

Lexical access refers to the process of retrieving a word from the lexicon. The activation of the word is directly dependent on the context. According to the three-staged lexical access model, a word from the lexicon would be retrieved in three stages (Dell et al., 2004). The first stage involves conceptual activation, which leads to the activation of the conceptual properties associated with the given word. If the target word is 'dog,' for example, conceptual aspects such as four legs, fur, and tail may be triggered. The lemma nodes associated with the concept may be activated in the next stage, known as the lemma node activation stage. During this process, lemma nodes (words) other than the target might also be activated at this step. Various lemma nodes, like 'cat,' 'fox,' 'goat,' and so on, may be triggered for the aforementioned conceptual properties. During the lexical selection stage, the

lemma node that best matches the conceptual qualities is chosen. The phonemes associated with the shortlisted lemma node would be triggered from the phonological input lexicon in the final phase, which would be phoneme retrieval. The raw form of phonemes is considered in the phonological input lexicon. These phonemes are chosen based on the lemma node that has been selected. Words that are taxonomically or thematically similar to the target word may facilitate or compete with the target word's activation during this process, particularly during the lemma node activation (Blumstein et al., 2000). In other words, the co-activated words may either facilitate (facilitation) or inhibit (inhibition) the activation of the target word.

Many experimental tasks can be used to measure lexical access in speech production. To point out a few lexical decision tasks, naming tasks, writing tasks, semantic categorisation tasks, etc. Lexical decision and naming tasks are two popular experimental tasks. Participants would be required to determine whether two given words are semantically linked or not in the lexical decision or judgement tasks. On the other hand, the naming task requires the participant to name the presented image. When naming the target image, the speakers must choose a word with the same conceptual properties as the target image. In the next phase, the words with common conceptual properties are activated. As a result, when naming a specific image (e.g., banana), semantically related ideas (e.g., grapes, apple, orange) are activated, and the intensity of activation is proportional to how semantically linked they are to the target word (Bub et al., 1987). This is termed semantic distance. The semantic distance may differ with respect to the different lexical items within a semantic category in the example mentioned above. The word 'strawberry' may also be related to 'banana'; however, the distance is considered more when compared to 'apple' or 'orange'.

In summary, many words may be activated during this phase. Experimenters have used different paradigms based on this. Methods like priming, cyclic naming and blocked naming tasks are used to investigate the mechanism of co-activation. The priming task uses a prime or a precursor before the target, which may or may not be related to the target. The vocal reaction time and accuracy scores for the words with related and unrelated primes are compared to deduce the pattern of co-activation. While the cyclic naming or blocked naming task would require the participants to name pictures belonging to the same lexical categories (related block) or pictures belonging to unrelated lexical categories (unrelated block) in succession. The co-activation pattern is deduced based on the performance of the naming task for related and unrelated blocks and the pattern of co-activation naming task performance for the related and unrelated blocks. Interestingly the studies employing priming have favoured semantic facilitation (Butterworth et al., 1984), while the studies using cyclic or blocked naming have favoured inhibition (Caramazza, 1997). The pattern of co-activation may again depend on the participant variables. The co-activation pattern is assumed to vary as a function of age, with older adults showing inhibition and younger adults showing facilitation.

1.1 Lexical access in aphasia

Individuals with aphasia commonly have trouble finding words (Harnish, 2015; Raymer & Rothi, 2015). A lexical semantic breakdown is common in persons with aphasia. An explicit sign of lexical semantic breakdown is paraphasia, a linguistic deficit exhibited in persons with aphasia. Unintended word replacement is referred to as paraphasia. The substituted word may or may not be related to the target word (De Groot, 1984). Furthermore, the substituted word may be related to the target word either semantically or phonemically. Semantic paraphasia is the production of a word that is semantically linked to the target word. Phonemic paraphasia refers to the production of a word that is phonemically similar to the target. Random paraphasia occurs when the replacement word has no association with the target. A semantic paraphasia indicates a problem with lemma node activation, whereas a phonemic paraphasia indicates a problem with phoneme retrieval. The difficulty be at the conceptual activation level if the paraphasia is random. Thus, paraphasia might be considered a lexical semantic breakdown episode in aphasia.

Semantic facilitation and inhibition can be tested in persons with aphasia. The word-picture interference paradigm can be used to tap these two mechanisms of lexical semantic activation in persons with aphasia. The cyclic and blocked naming task can be used in persons with aphasia. In addition to these two tasks, the word-picture interference paradigm can be used to tap these two mechanisms. In the word-picture interference paradigm (Foygel & Dell, 2000; Janssen et al., 2008), a word termed precursor is presented before the target presentation. This precursor can be related or unrelated to the target. If the naming latency is more

for target pictures preceded by related precursors than the naming latency of target pictures preceded by unrelated precursors, it would suggest inhibition. The opposite pattern would suggest facilitation. The word-picture interference paradigm is more inclined towards inhibition. The cyclic naming task has also been used in persons with aphasia in a handful of studies. For instance, a study conducted in this direction suggested inhibition with better naming accuracy for pictures on an unrelated block compared to pictures in a related block (Schriefers et al., 1990).

Anomic aphasia is considered a milder variant of aphasia and is characterised by naming difficulty. Persons with anomic aphasia would find it difficult to retrieve the right word from the lexicon and are presumed to exhibit access deficits. Lexical access in persons with anomic aphasia has been explored through studies. However, the studies in this direction are sparse. For instance, a study by Hubbard and Arnold (2013) showed that persons with anomic aphasia showed delayed lexical activation, however, studies on tapping the two mechanisms of lexical activation in persons with anomic aphasia have not been done to the best of our knowledge. Therefore, there is a need to test the two mechanisms of lexical activation in detail.

1.2 Need and objectives for the study

The pattern of lexical co-activation in anomic aphasia would help researchers extract details on lexical access in persons with aphasia. The details also would help researchers in sequencing the stimulus for therapy. Thus, an exploratory study investigating the mechanism of lexical co-activation was planned for this population. The current study used a blocked naming task over the priming task as the priming task is predominantly non-verbal and is prone to speculation diluting the premise. Therefore, the specific objective of the current study is to compare the vocal reaction time and accuracy scores for related and unrelated blocks in persons with anomic aphasia and neurologically healthy individuals.

2.0 MATERIALS & METHODS

The study was carried out to investigate the pattern of lexical semantic co-activation in persons with anomic aphasia. Anomic aphasia represents a group of pathological populations with word-finding difficulty. The pattern of lexical semantic activation was investigated in this group. The blocked naming task was used to tap this pattern.

2.1 Participant details

A total of 20 Kannada-speaking participants were recruited for the study based on convenient sampling. The participants were divided into two groups of ten each. The first group comprised ten participants in the age range of 37-48 years; all were males, as depicted in **Table 1**. The participants of this group had a history of cerebrovascular accidents. Western Aphasia Battery in Kannada (Ravi et al., unpublished) revealed anomic aphasia at the testing time. All the participants had received therapeutic intervention but did not receive any therapy two months before the current study. Age and gender-matched controls were recruited as participants for group 2.

Table 1: Details of the participants

Sl No	Age/Gender	Post stroke duration	Initial Diagnosis	Number of sessions	Diagnosis at the time of conduct of present study
1	43/Male	7 months	Broca's aphasia	26	Anomic Aphasia
2	37/Male	8.5 months	Broca's aphasia	25	Anomic Aphasia
3	43/Male	6 months	Broca's aphasia	22	Anomic Aphasia
4	44/Male	8 months	Broca's aphasia	32	Anomic Aphasia
5	48/Male	8 months	Broca's aphasia	15	Anomic Aphasia
8	43/Male	12 months	Global Aphasia	38	Anomic Aphasia
9	39/Male	6 months	Conduction Aphasia	19	Anomic Aphasia
10	47/Male	8 months	Conduction Aphasia	27	Anomic Aphasia

As seen in **Table 1**, the post-stroke duration ranged from 6 months-12 months. The number of therapy sessions attended by the participants ranged from 15-38 sessions. The initial diagnosis varied from Global aphasia to conduction aphasia. However, the diagnosis was anomic aphasia at the time of conduct of the present study. Stroke was the cause of aphasia in all the participants. Persons with aphasia due to traumatic brain injury or metabolic conditions were not considered to keep the inclusion criterion uniform.

2.2 Sampling
Convenient sampling was used for the recruitment of participants.

2.3 Stimulus
The current study used a blocked naming task specified in the 'need 'section'. The stimulus was derived from 260 picture naming tasks (Nikitha et al., 2013). Eighty pictures were shortlisted based on the requirement of the current study (for dividing the stimuli into semantically related and unrelated blocks). The pictures were presented in blocks. The first block consisted of 40 pictures which belonged to the same lexical category (20 pictures of animals followed by 20 common objects). In comparison, the second block consisted of 40 pictures belonging to random lexical categories (other than animals and common objects). The pictures were presented through the DMDX software version 6.1 Auto-Mode. The stimuli were presented for a duration of 4000 milliseconds, and the inter-stimulus duration between the stimuli was 500 milliseconds

2.4 Procedure
The pictures were presented in two blocks. The first block consisted of semantically related stimuli, while the second one comprised semantically unrelated stimuli. The presentation duration and inter-stimulus interval (ISI) were as specified above. The vocal reaction time and accuracy score for related and unrelated blocks were computed and analysed.

2.5 Dependent variables
The vocal reaction time and accuracy scores were dependent variables.

2.6 Analysis
The naming latency/vocal reaction time and accuracy for semantically related and unrelated blocks were computed and analysed. The hypothesis was that if the naming latency/vocal reaction time and accuracy were better for semantically related blocks compared to semantically unrelated blocks, the results suggest facilitation. The vice-versa (with better vocal reaction time and accuracy for unrelated compared to related block) is indicative of inhibition.

3.0 RESULTS
The participants were divided into two groups. Group 1 participants secured a mean vocal reaction time of 1922.36 milliseconds for the related block and 1512.22 milliseconds for the unrelated block (**Figure 1**). The accuracy scores were 73% and 87% for semantically related and unrelated blocks, respectively (**Figure 2**). Group 2 participants secured a vocal reaction time of 1335.22 milliseconds and 1413.33 milliseconds for related and unrelated blocks, respectively. The accuracy scores were 92% and 93% for related and unrelated blocks, respectively. For group 1 participants (persons with anomic aphasia), the vocal reaction time was higher, and accuracy scores were better for unrelated blocks than related blocks. For group 2 (neurologically healthy participants), the vocal reaction time was marginally higher for unrelated compared to related blocks. At the same time, the accuracy scores showed no difference.

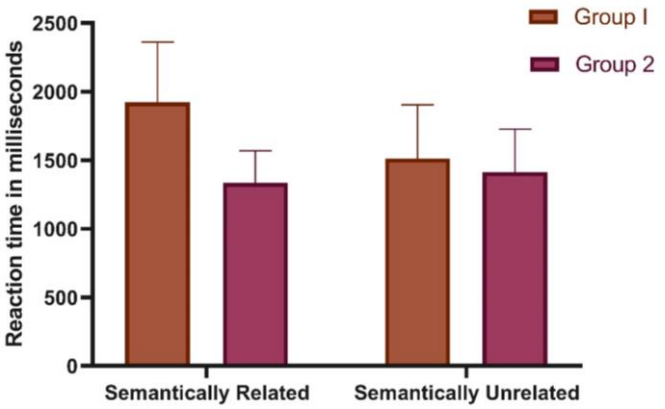

Figure 1: Comparison of vocal reaction time measures for group 1 and group 2

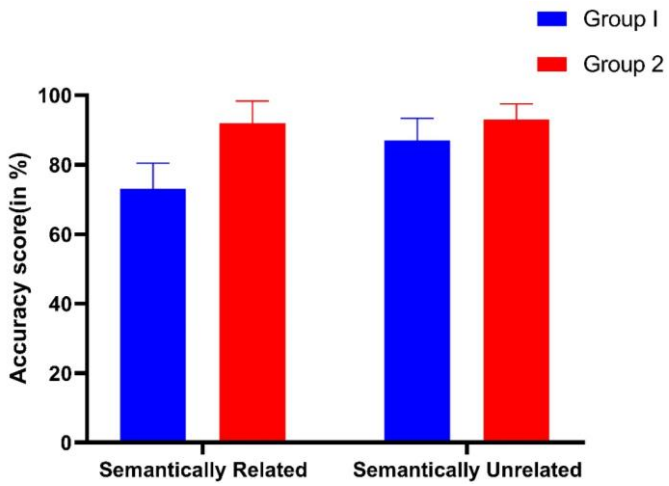

Figure 2: Comparison of accuracy scores for group 1 and group 2

The objective of the study was to compare the vocal reaction time and accuracy scores of related versus unrelated blocks only within group comparison was carried out for primary analysis. The data did not abide

by properties of normal distribution (as per the results of Shapiro-'Wilk's test with ($p<0.05$), hence, 'Wilcoxon's signed rank test was carried out for within-group comparisons. For group 1, the Z score on comparing the vocal reaction time and accuracy score for related vs unrelated blocks were 4.33 and 2.68, respectively. The effect size ranged from 0.59 to 0.96, indicating a larger effect size. The corresponding p-value ($p<0.05$) showed a significant difference for the two blocks on both the measures. The Z score for group 2 for vocal reaction time and accuracy scores (for related vs unrelated block) was 1.11 and 0.08, respectively. The effect size ranged from 0.017 to 0.24, and the effect size was small for these two observations. The corresponding p values showed no significant difference.

In addition to the pre-set objectives, between groups comparison was carried out. Between groups, comparison was carried out using Mann Whitney-U test. The Z scores obtained comparing the vocal reaction time were 3.16 and 2.98 for accuracy. The corresponding p values showed a significant difference between the two groups for vocal reaction time and accuracy measurements.

4.0 DISCUSSION

Semantic facilitation and inhibition are the two mechanisms of lexical activation. The concept of facilitation came into existence from studies based on the priming principle. The priming principle, in turn, is based on the spreading activation principle. This principle believes that words which are preceded by a semantically related prime are identified faster than words which are preceded by a semantically unrelated prime (Blumstein et al., 2000). The magnitude of priming shares an inverse relationship with the semantic distance, meaning that the lesser the semantic distance would be the magnitude of priming (Butterworth et al., 1984). The limitation of priming is that it favours facilitation. Inhibition is the other mechanism of lexical semantic activation. Operationally inhibition works in the pattern opposite to facilitation. Inhibition refers to impediment of the activation of a target word when it is preceded by semantically related context. The word-picture interference paradigm tests for inhibition. The limitation of this task is, again, that it is inclined towards inhibition.

The present study was carried out with the aim of investigating these two mechanisms of lexical activation in persons with anomic aphasia. The participants were divided into two groups. The first group comprised ten persons with anomic aphasia, while the second group consisted of ten neurologically healthy individuals. A blocked naming task was administered to the participants. For group 1, vocal reaction time and accuracy scores were better for unrelated blocks than related ones. For group 2 there was no evident difference between the vocal reaction time and accuracy scores for related and unrelated blocks. The difference between the vocal reaction time for semantically related and unrelated blocks was significant statistically only for group 1, indicating that the mechanism of lexical activation was different for the two groups.

Better vocal reaction time and accuracy scores for unrelated items compared to related items in persons with anomic aphasia suggest inhibition. When the lexical items are presented in sequence, one item may impede the lexical activation of the next item leading to confusion. Thus, inhibition would have been seen in this population, while the order of presentation may not be a salient factor for neurologically healthy individuals owing to which statistically significant difference between related and unrelated items may have occurred in this group. In other words, both facilitation and inhibition would not have occurred in this population, or there would have been a consolidated effect neutralising facilitation and inhibition

5.0 CONCLUSIONS

The study was conducted to investigate the pattern of lexical co-activation in persons with anomic aphasia. Persons with anomic aphasia would exhibit word retrieval errors. Deducing the pattern of lexical co-activation would facilitate decision-making in regard to stimulus presentation in therapy. Lexical co-activation was assessed through the blocked naming task. A total 0f 20 participants (ten persons with anomic aphasia and ten neurologically healthy individuals) were considered for the study. The stimulus was presented on DMDX software as related and unrelated blocks. Persons with anomic aphasia performed better on unrelated compared to related blocks suggesting inhibition in this population. This indicates that the presentation of related items in succession would lead to inhibition; hence the order of presentation should be carefully chosen in this population.

5.1 Limitations and Future Direction

The major limitation of this research is the sample size of the participants for the study and the convenient

sampling used for the participant selection. Therefore, the results of the current study need to be used with caution. We strongly recommend that future researchers carry out the research with a larger sample size for better generalisation of the results.

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Authors' contribution: B.B. & A.B.P. were involved in study design, stimulus preparation, data collection, analysis of the data, interpretation, writing of the manuscript and proofreading of the manuscript.

Conflict of interest*:* The authors report no conflicts of interest.

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