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Lexical Semantic Ambiguity Resolution in Individuals with Left Frontal Lobe Lesion

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ABSTRACT

This study aimed to analyze the reaction time and accuracy of recognition of semantic ambiguous word in individual with left frontal lobe lesion. Four individuals with left frontal lobe lesion (IWL) and eight neurologically normal (NN) participants were selected for the study. A list of 40 Hindi words consisting equal number of ambiguous and non-ambiguous words with further consideration frequency was prepared. Paradigm Software (v2.5.0) was used to present stimulus. Reaction time and percentage of accurate response was analyzed and results showed that both frequent and non-frequent categories of semantic non-ambiguity taken relatively less time to process than NN group. Contrary to this, IWL were noticed to have varied pattern of processing with reduced reaction time for ambiguous than non ambiguous categories. This shows the effect of lesion in frontal lobe suggesting significance of frontal lobe in processing ambiguous words.

Keywords: Semantic ambiguity, frontal lobe, reaction time, accuracy, visual word recognition

INTRODUCTION

Lexical semantic ambiguity (LSA) is single word having different meanings or different sense or aspect that word can be

used in. It is variation of meaning of word according to their function in a particular context. Studies show that multiple meanings which are unrelated facilitate recognition of words and it depends on the approach used to select words that are semantically ambiguous (Juan & Pilar 2017). Unambiguous words have slower visual lexical decisions as compared to ambiguous words matched for overall frequency as found out by previous ambiguity advantage reports (Rubenstein, Garfield & Millikan 1970; Jastrzembski 1981). Ambiguous words have beneficial impact from having multiple entries within the lexicon is one explanation of the ambiguity advantage. However, Kellas et al. (1988) explained that each meaning of semantic ambiguous word represented by individual node and prolonged recognition times were produced due to the increased inhibition of competitors since multiple nodes of ambiguous words act independently to inhibit all other competing entries instead of inhibiting each other. It is more likely that one of these competitors reach the threshold than a word that has only one entry in the race for recognition. For spoken as well as visual word recognition tasks have been explored in this regard (Gaskell & Marslen-Wilson 1997; Hinton & Shallice 1991; Joordens & Besner 1994; Plaut 1997; Plaut & Shallice 1993).

Another study on ambiguous and non-ambiguous words based on frequency of meaning, using verbal stimuli, evaluating rating's use to analyze meaning frequency, revealed that in case of orthographic and meaning frequencies should converge there was a correlation between word frequency count and ratings and not unduly influenced by semantic factors also giving proper measure of relative meaning dominance (Griffin 1999). Research had shown that an interlocutor's dominant meaning tends to be the default interpretation of the word unless immediate sentence context exist to steer interpretation towards a different meaning that is when ambiguous words are encountered within a neutral context, or in the absence of context altogether, people are more likely to interpret it with its dominant meaning (Colbert-Getz & Cook 2013).

According to research suggest, part of the brain responsible for processing of ambiguous words are bilateral inferior frontal

gyrus and left inferior frontal gyrus and left cingulate gyrus for subordinate meaning (Bilenko et al. 2009). Another study using event related functional magnetic resonance imaging suggest that even in the absence of behavioral effect of ambiguity, ambiguous words were associated with the recruitment of cortical structures implicated in top down modulation of noisy activity when compared to unambiguous words (Hargreaves et al. 2011). A study also tells about activation of left inferior frontal gyrus for resolution of competition and selection of one meaning and not for unresolved meaning of an ambiguous word, also reduced activation in frontal, temporal and parietal areas in the case of unresolved meaning of ambiguous word. It also suggest left inferior frontal gyrus activation where selecting of a meaning is done implicitly (Grindrod et al. 2008). Study done on semantic ambiguity resolution in patients with bipolar disorder using Event Related potentials suggests insufficient suppression of irrelevant homonym meaning in right hemisphere (Schneegans & Hoenig 2018).

Previous studies on semantic ambiguity suggest the activation or participation of bilateral frontal gyrus, especially left inferior frontal gyrus and left cingulate gyrus, right anterior cingulate, superior temporal gyrus and occipitotemporal region for analysis and selection of semantically ambiguous word meanings. There is no concise about the site for processing of semantic ambiguity. This review highlights the need for study of semantic ambiguity in neurologically disturbed population. Also activation of node based on ambiguity and frequency need to be identified. Hence the present study aimed to explore the reaction time and accuracy of semantic ambiguity in one of the neurologically disturbed the population i.e. frontal lobe lesion compare to age and gender matched neurologically normal (NN) individuals with objective of (a) Is Reaction Time (RT) and Percentage of accuracy of responses (PAR) are different for semantic ambiguous word from non semantic ambiguous word (b) Is frequency of occurrence has any advantage in recognition along with ambiguity (c) Is there similar pattern of recognition of ambiguity and frequency seen in NN and person with frontal lobe lesion.

METHOD

Participants

Four individuals with left frontal lobe lesion (IWL) were selected out of which 1 was male (age= 59 years) and 3 were females (mean age = 39.3 years). Eight neurologically normal (NN) participants of age and gender matched group were selected. All of them were native speakers of Hindi. All the IWL were had history of stroke followed by aphasia, which later on recovered. However, these patients are reported of weakness in limbs and magnetic resonance imaging (MRI) of participant 1 (59year old male) revealed hypodense area in left frontal peri-ventricular white matter representing acute non hemorrhagic infarct with. MRI of participant 2 (59 year old female) revealed few FLAIR hyperintense foci in left frontal white matter ischemic in nature. MRI of participant 3(27 year old female) revealed thrombosis of frontal white matter. Computed tomography scan plain (CT Scan) of participant 4(32year old female) revealed left frontal depressant fracture and frontal contusion. There was no history or complaint of any neurological problem in all 8 normal participants. Similarly there was no pre stroke speech, language and cognitive deficits in IWL. This study approved by the ethical committee of the institute and stated of no ethical related issues.

Material

A list of 40 Hindi words consisting of 20 ambiguous and 20 non-ambiguous words were prepared and included equal number of frequent and non-frequent words. Font Size 48 was selected and each word was converted to JPEG format and Paradigm Software (v2.5.0) was used to present the stimulus. Experiment was created by adding images to block. Target presentation time was set as 2000 millisecond for each stimulus. Stimulus alignment was set as center in black font on white background. Each stimulus was presented orthographically in Hindi language and presented randomly. Left and right keyboard arrow keys were selected as response.

Procedure

Each subject was informed prior to the testing and consent was taken for the same. For the experiment participants were asked to sit in a less distractive room for proper attention during the test. Participants were instructed to pay attention to the visual presentation of words and click left arrow key if they think the word has single meaning and click right arrow if they know more than one meaning of the word presented on the screen. Before starting the test participant was given example of an ambiguous as well as of an unambiguous word which were not present in list for his/her better understanding of the task. RT and PAR were analyzed in SPSS software (IBM SPSS statistic 20).

Results

RT and PAR were analyzed under four categories such as frequent semantic ambiguous (FSA), frequent semantic non-ambiguous (FSN), non-frequent semantic ambiguous (NSA) and non-frequent semantic non-ambiguous (NSN). As see in table 1, mean reaction time of FSN was less followed by NSN in neurologically normal population. It shows that both categories of semantic non-ambiguity taken relatively less time to process. However both semantic ambiguous categories (NSA and FSA) were had prolonged RT in NN group. Contrary to this, IWL were noticed to have varied pattern of processing with reduced RT for ambiguous than non ambiguous categories. Table 2 depicted the mean and standard deviation of all four categories of percentage of accurate response in both studied groups. IWL had greater accurate response than NN group.

Shapiro Wilk's test of normality was administered and did not follow normality. Mann-Whitney U test was administered to see the difference between groups and result revealed significant inter group difference for the categories of RT and except FSN and NSN of PAR and p and /Z/ values are given in Table 3. Friedman test was used to test across categories within each groups and results suggested no significant difference in response time in normal individuals (/p/ = 0.175; $\chi^2 = 4.950$) as well as in individuals with frontal lobe lesion (/p/ = 0.127; $\chi^2 = 5.700$). Similarly there was no significant difference in accuracy

response in both NN (/p/ = 0.943; χ^2 = 0.389) and IWL case (/p/ = 0.113; X^2 = 3.737).

Table 1. *Mean and standard deviation of Reaction time in IWL and NN groups*

	FSA- RT	**FSN-RT**	**NSA- RT**	**NSN-RT**
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
IWL	3877.37 (1493.10)	5022.40 (2009.53)	5002.75 (1616.65)	5539.47 (1866.36)
NN	19249.37 (9585.42)	12148.23 (6678.64)	17850.25 (8172.50)	16317.46 (9106.72)

Table 2. *Mean and standard deviation of accurate response in IWL and NN groups*

	FSA- PAR	**FSN-PAR**	**NSA- PAR**	**NSN-PAR**
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
IWL	72.50 (32.01)	71.25 (9.91)	70.25 (23.57)	79.25 (29.12)
NN	92.50 (7.07)	95.00 (5.77)	87.62 (17.07)	100.00 (0.0)

Table 3. */Z/ and p values of Mann-Whitney U test*

		/Z/	P
RT	FSA	2.717	0.007*
	FSN	2.208	0.027*
	NSA	2.378	0.017*
	NSN	2.038	0.042*
PAR	FSA	2.632	0.008*
	FSN	0.553	0.580
	NSA	2.381	0.017*
	NSN	1.338	0.181

*significantly different with $p \leq 0.05$

DISCUSSION

As per the results, there were significant difference of RT between NN and IWL for frequent semantic ambiguous (FSA),

frequent semantic non-ambiguous (FSN), non-frequent semantic ambiguous (NSA) and non-frequent semantic non-ambiguous (NSN). However significant inter group difference of PAR had observed only for of FSA and NSA. Major difference was seen in reaction time across participant group that is participants with frontal lobe lesion took more time to respond to ambiguous and non-ambiguous words which could be due to presence of lesion in frontal lobe suggesting participation of frontal lobe in processing ambiguous words. However, group of IWL were showed different pattern of recognition where frequent occurring words had faster recognition than non-frequent. Accuracy of correct response is reduced in IWL and ambiguity words were processing with reduced RT than non-ambiguous. It indicates that there was no activation of multiple meaning nodes as competitors of a same word. Hence there was no requirement of inhibition of words which leads to similar RT of NS and SA words. Significant difference in reaction time across normal participants for ambiguous and non-ambiguous words was seen suggesting better reaction time for ambiguous due to proper function of frontal lobe processing and a bit prolonged reaction time for non-ambiguous words suggesting longer processing in agreement with previous study (Copland et al. 2007) proposed to have increased activity of right supramarginal region. This study proves insight into the language processing difficulty in patients with frontal lobe lesion. Specifically, pointing towards the need of appropriate cues to deliver accurate responses and facilitating less processing time. Also word recognition duration for ambiguous word is easier than non-ambiguous word (Juan & Pilar 2017).

Though there was no significant difference across task in each group, there was prolonged reaction time for ambiguous tasks (FSA and NSA) followed by non-ambiguous tasks (FSN and NSN) in NN group. This result is against the advantage of ambiguity explained in literature (Rubenstein, Garfield & Millikan 1970; Jastrzembski 1981; Gernsbacher 1984). However this is in congruent with a study which explained the nature of recognition of isolated ambiguos word (Gaskell & Marslen-Wilson 2002). This can be considered as intricacy of recognition

of words where both frequent nodes are activated and competed to each other to get recognized (Swinney 1979; Onifer & Swinney 1981; Rayner 1998).According to the present model orthographic/phonological and semantic units are part of processing of word recognition. Multiple semantic representation of corresponding to its different meanings has same orthographic representation in an ambiguous word. Hence, at glance, it predicts the inconsistencies of recognition of ambiguous words.

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