Semantic access by dual-route model during visual word processing

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Purpose and Introduction: Reading involves computing orthographic input (visual word) [1] by selection of correct lexical entery from semantic mental storage [2]. Lexical decoding uses communication between frontal and posterior areas [3] and prelexical recognition of visual word forms uses bilateral occipito-temporal network [2]. The comparison of words with pseudowords shows the mapping of orthographic representations of perceived words onto stored word form representations by fast pathway called dual-route model [2]. Hence, the study was planned to explore the dual-route models while semantic reading.

Methods and Methodology: The pilot study was carried out on eight healthy adult subjects (five males and three females; age range 25 to 45 years) after IEC approval. Inclusion criteria were: right handedness, high proficiency in Hindi reading and given written consent. Exclusion criteria were left handedness, any sensory impairment (hearing/ vision), neurological or psychiatric problems, and any contraindication for MRI. The Blood oxygen level dependent (BOLD) data was acquired with clinical 3T whole body MR scanner with 32 channel head coil (Achieva 3.0T TX, Philips, Netherlands). Single-shot echo planar imaging (EPI) sequence was used with slice thickness 5 mm, number of slices = 29, TR: 2000 ms, TE: 30 ms, flip angle = 90°, FOV = 230 mm, Dynamics: 222, Resolution: 64x64, overlaid on anatomical images using conventional T1-weighted 3D sequence. The visual text stimuli were presented using Eprime (version 1.1, Psychology Software Tools Inc, USA) and MR compatible LCD monitor (NordicNeuroLab, Norway). The task comprised of Meaningful words (MW) (5 event x 4 blocks) and Pseudowords (PW)(5x4) where each event was of 2.5 sec duration. The paradigm included baseline 28 sec (i.e. background noise with black screen display), then block of MW of 2-3 syllables in Hindi language, second baseline 28 sec followed by block of PW (2-3 syllables in Hindi), similarly ABCABC four cycles. The response was oral reading of the text displayed and the total duration was 444 sec. Pre- and post-processing was done using SPM8 (Wellcome Department of Cognitive Neurology, London, UK). The BOLD clusters were converted from MNI template to the Talairach and Tornoux coordinates, for estimation of anatomical areas. The group data was analyzed by one-way ANOVA test ($p<0.001$, cluster threshold 10).

Results and Discussion: Reading performance outside the MRI showed equal rate of MW when compared to PW in seven subjects. The BOLD data showed that on comparison of MW vs PW left hemispheric dominance of middle frontal gyrus (MFG), caudate, cingulated gyrus, culmen and right dominance of inferior parietal, superior frontal, precentral gyrus. On comparison of PW vs MW left precentral, inferior frontal gyrus (BA44, BA 45 and BA46), fusiform and right medial frontal gyrus showed significant BOLD activity. The fusiform gyrus provides access code to semantic or phonological information represented in posterior left middle temporal gyrus (MTG). Neural activity in the left inferior frontal gyrus (IFG, BA44), anterior insula, thalamus and caudate nucleus, supports grapheme to phoneme conversion during visual word processing [2,4].

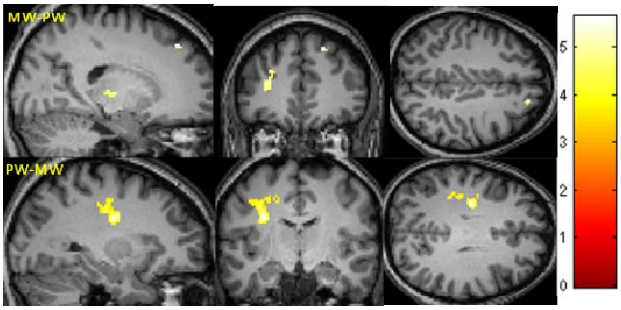
Table1:BOLD activation for pseudo-words vs. meaningful words (p<0.001)

Clusters	Z-score	MNI	Hemisphere	Area	Brodmann Area
419	4.57	-30 -14 30	Left	Precentral Gyrus	BA 6
72	4.12	-54 10 14	Left	Inferior Frontal Gyrus	BA 44
34	3.91	-44 24 10	Left	Inferior Frontal Gyrus	BA 45
35	3.82	-46 -74 -8	Left	Fusiform Gyrus	BA 19
16	3.67	-52 32 12	Left	Inferior Frontal Gyrus	BA 46
32	3.42	16 -22 56	Right	Medial Frontal Gyrus	BA 6

Table2: BOLD activation for meaningful words vs. pseudo-words (p<0.001)

Clusters	Z-score	MNI	Hemisphere	Area	Brodmann Area
69	3.59	-32 42 12	Left	Middle Frontal Gyrus	BA 10
15	3.69	-20 10 20	Left	Caudate	Caudate Body
11	3.50	-20 -38 32	Left	Cingulate Gyrus	BA 31
10	3.24	-10 -22 14	Left	Thalamus	*
17	3.55	0 -58 -4	Left	Culmen	*
12	3.50	50 -46 56	Right	Inferior Parietal Lobule	BA 40
10	3.84	20 40 46	Right	Superior Frontal Gyrus	BA 8
13	3.77	26 -6 72	Right	Precentral Gyrus	BA 6
20	3.73	40 -48 0	Right	Parahippocampal Gyrus	BA 19
57	3.65	14 -20 12	Right	Thalamus	Medial Dorsal Nucleus

Figure: BOLD activation in during semantic analysis by reading words and pseudowords overlaid on T1-3D anatomical section



Conclusion: The results indicate that pseudoword reading reflects the need for a more exhaustive search in the mental lexicon. The study evidence the dual-route model of lexical decision and there is switching of faster pathway for grapheme to phoneme conversion.

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