Neurolinguistic correlates of script processing in tri-linguals: an fMRI study

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Introduction: Reading, processing and eventual comprehension of any linguistic stimuli requires effective integration of the inherent orthographic, phonologic, semantic, syntactic and pragmatic information contained in it, which depends upon the innate language characteristics and proficiency level acquired in the language concerned [1,2]. We probed the multilingual brain for processing of semi-syllabic vs. orthographic scripts with tasks arranged in hierarchical increasing order of complexity, in order to examine the neuro-linguistic correlates of the perception of native and non-native scripts amongst tri-linguals.

Material and Methods: Whole brain imaging was performed using multi-slice single shot gradient echo EPI, on a 1.5 T MR imaging system (Magnetom Vision, Siemens, Erlangen, Germany). The BOLD series of 72 sequential images, with alternating epochs of baseline vs. activation phases of six measurements each, were acquired in 12 right-handed healthy, trilingual volunteers (25±5yrs) from similar socio-economic strata, proficient in the lingual combinations of Malayalam (mother tongue), Hindi (language at work) and English (foreign language, used less frequently) were recruited. Visual inputs were given through non-magnetic LED goggles at the rate of 15cues/min. Within each language, four separate studies were performed with the activation phases being a (i) 3-5 letter strings, (ii) statements and questions, (iii) sentence generation task following viewing of non-sentences and (iv) non-word processing followed by word generation task. Baseline task was to think randomly while viewing '1'. Statistical Parametric Mapping (SPM99) was used with the first level analysis of datasets being performed at a corrected p value of 0.01 and extent threshold of 5 voxels, while the second level processing was carried out (t test) for an uncorrected p value of 0.001.

Results: Predominantly left-lateralized neuronal patterns were observed for word and sentence processing tasks with clusters of activations in the language centres that included the posterior, inferior frontal cortex (Broca's Area BA44,45), Supramarginal Gyrus (BA40), parietotemporal cortex (Wernicke's Area BA21,22), diverse regions in the frontal cortex (BA9,10,11) and motor area (BA 6) as shown in Fig.1. Significant activation was observed in the right cerebellum with bilateral activation in the occipital lobe (BA17,18,19).

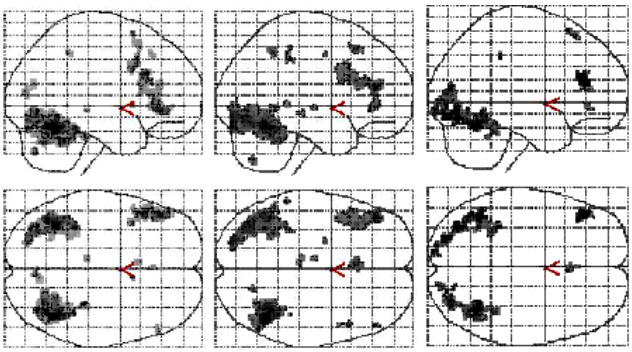

Fig.1 Glass brain view in mother tongue(Malayalam), language at work (Hindi) and foreign language (English) (from left to right)

Discussion: Non-word and non-sentence processing tasks elicited significantly more activation in the Broca's area (BA44/45), SMG (BA40), pre frontal cortex (BA9,10,11), and cerebellum. Cluster recruitment shows a sharp increase for increasing complexity from word to non-word processing [Fig.2]. Increased cluster count at Broca's area and pre-frontal cortex accompanied an increase in complexity of the task performed (order: words, sentence, non-sentence and non-word processing). While maximum pre-frontal activation was observed to occur for familiar languages, foreign language processing elicited more activation in the Broca's area.

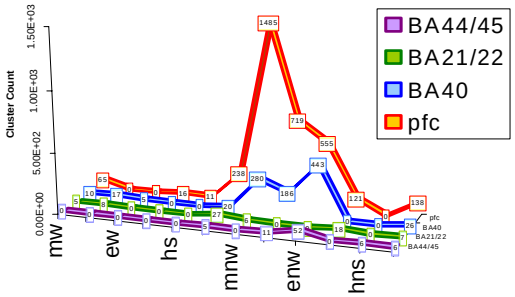

Fig.2 Cluster recruitment in mother tongue, language at work and foreign language for words, sentences, non-words, non-sentences (x-axis) (second subscript: w-word, nw-nonword,s-sentence, ns-non-sentence)

References:

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2. Longcamp M, Anton JL, Roth M, Velay JL. Neuroimage 2003 Aug;19(4):1492-1500