Cognitive control for processing and inhibition of facial emotional expressions

SENTHIL S KUMARAN[1], BHOOMIKA R KAR[2], SUNITA GUDWANI[1], and ANKEETA SHARMA[1]
[1]*DEPARTMENT OF NMR AND MRI FACILITY, ALL INDIA INSTITUTE OF MEDICAL SCIENCES, New Delhi, Delhi, India,* [2]*Centre of Behavioural and Cognitive Sciences, UNIVERSITY OF ALLAHABAD, Allahabad, Uttar Pradesh, India*

Purpose and Introduction: Competing demands contrary to habit require complex decision-making strategies and coordinated actions that implicate higher cognitive functions like selective attention, planning, response suppression and response selection [1]. The inhibition of the strong "stimulus–response" associations is difficult and prone to errors [2]. Affective faces in an interference task further introduces conflict in conjunction with emotion of faces, so the study was planned to find such cognitive control where the regulation of emotions is demand of daily routine.

Methods: The study was carried out on eighteen healthy adult subjects (sixteen males and two females; age range 20 to 45 years) after IEC approval. Inclusion criteria were: right handedness 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 1.5T MR scanner with 12 channel matrix head coil. Single-shot echo planar imaging (EPI) sequence was used with slice thickness 5mm, number of slices 29, TR: 2s, TE: 30 ms, flip angle 90°, FOV 230 mm, Dynamics 230, Resolution 64x64, overlaid on anatomical images using conventional T1-weighted 3D sequence. The visual stimuli of affective faces were presented using MR compatible system with binocular goggles and eye-tracker (NordicNeuroLab, Norway). The stimulus comprised of happy, sad and neutral black and white pictures of emotional faces. The paradigm included two baselines 30 sec and 90 sec of black screen display and another as one emotional face (happy, sad and neutral) expression, respectively. The task was in three blocks (6 event x 3blocks) where each event was of 1.9 sec duration comprising of three faces where central face as stimulus to be responded by pressing button on MR compatible keypad (button1 as happy expression and button 2 as sad expression). Pre- and post-processing was done using SPM12 (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).

Table 1: BOLD activation for incongruent emotional expression (p<0.001)

Clusters	Z score	Hemi-sphere	Area	Brodmann Area
228	5.22	Right	Lingual Gyrus	BA 19
45	4.15	Right	Parahippocampal Gyrus	BA 36
21	3.95	Right	Uncus	BA 38
13	3.89	Left	Parahippocampal Gyrus	BA 30
36	3.82	Right	Medial Frontal Gyrus	BA 11,25
11	3.48	Left	Superior Temporal Gyrus	BA 38
12	3.48	Right	Superior Temporal Gyrus	BA 38
7	3.24	Left	Lingual Gyrus	BA 18
6	3.21	Right	Lingual Gyrus	BA 18

Table 2: BOLD activation for congruent emotional expression (p<0.001)

Clusters	Z-score	Hemisphere	Area	Brodman n Area
41	3.59	Right	Medial Frontal Gyrus	BA 11,25
6	3.33	Right	Insula	BA 13
5	3.34	Right	Cuneus	BA 17
37	3.61	Left	Lingual Gyrus	BA 18
126	4.24	Right	Lingual Gyrus	BA 19
31	4.29	Left	Parahippocampal Gyrus	BA 30, 36
7	3.55	Right	Parahippocampal Gyrus	BA 34
559	4.02	Right	Fusiform Gyrus	BA 37
46	4.05	Left	Subcallosal Gyrus	BA 47
35	3.61	Left	Precuneus	BA 7

Results and Discussion: The BOLD data showed that congruent and incongruent processing revealed activation in right precuneus, fusiform, bilateral lingual gyri (facial recognition, directing visual attention) [3- 6] and medial frontal cortex (cognitive control) [2, 7]. During incongruent processing significant BOLD activity was in bilateral superior temporal cortex which can be attributed to higher order visual processing systems for Stroop task (selective attention) [8].

Conclusion: The results indicate that suppression of automatic action in favor of controlled less automatic facial expression required higher order visual processing system including occipito-temporal-parietal neural pathway.

References: [1] Miller EK, Cohen JD, 2001. Annu. Rev. Neurosci. 24, 167–202. [2] Ovaysikia S, Tahir KA, Chan JL, et al., 2011. Frontiers in Human Neurosci, 4. doi: 10.3389/fnhum.2010.00234. [3] Lee TMC, Leung MK, Lee TMY, et al, 2013. www.nature.com/scientificreports. [4]Bogousslavsky J, Miklossy J, Deruaz JP, et al, 1987. J Neurol, Neurosurgery & Psychiatry, 50:607-614. [5] Zhang S, Li CR, 2012. Neuroimage, 59(4): 3548–3562. [6] Cavanna AE, Trimble MR, 2006. Brain, 129, 564–583. [7] Kandel ER, Schwartz JH, Jessell TM, editors. Principles of neural science. 3. East Norwalk, CT: Appleton and Lange; 1991.[8] Banich MT, Milham MP, Atchley R, et al, 2000. J Cognitive Neurosci 12:6,988–1000.

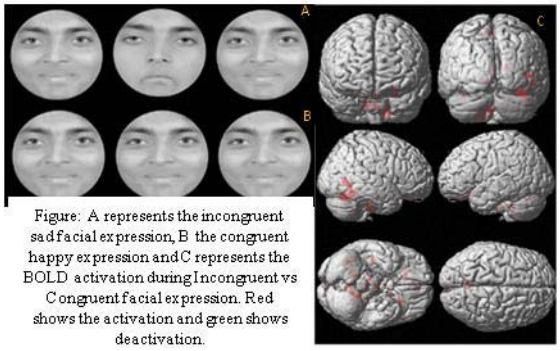

Figure: A represents the incongruent sad facial expression, B the congruent happy expression and C represents the BOLD activation during Incongruent vs Congruent facial expression. Red shows the activation and green shows deactivation.