Cross Modal Integration of Facial and Vocal Expressions of Fear

Sharathchandra R[2,1] , Shobini L Rao[3,1] , Thamodharan A[4,1] , Saranya V R[4,1], Rose Dawn[5]

1. Cognitive Neuroscience Centre, National Institute of Mental Health and Neuro Sciences (NIMHANS)

2.Research Associate 3.Professor 4.Junior Research Fellow 5.Associate Professor, Dept. of Neuroimaging and Interventional Radiology, NIMHANS.

OVERVIEW

The perception of emotion is a process that involves deciphering facial expressions, vocalization and bodily posture. In this study we examine the neural correlates of emotion perception in stimuli which combine the visual and auditory modalities. Facial expression of fear and fearful vocalizations were presented simultaneously. The aim is to understand the integration of emotional information from the visual and auditory modalities.

BACKGROUND

Choice of Affective Cross Modal Stimuli :

Behavioral studies [Gelder at al, 2000 & Massaro at al, 1996] have shown that cross modal binding takes place during emotion perception while simultaneously using facial expressions and affective verbal voice fragments. Ethofer et al [2006] found that volunteers found fearful faces to be more fearful and neutral faces also fearful when the faces were accompanied with a fearful vocalization. The faces used were Ekman faces (Ekmann, et. al., 1976) and the emotional vocalization were sentences utterred in fearful tones. Another approach to crossmodal binding has used Ekman's faces coupled with consonants uttered in fearful tones (Corrina et al 2010). In both the above approaches the emotional vocalization has been linguistic. Addition of the linguistic component to the vocalization may confound the effect of the fearful sound with the fearful linguistic content. Hence we aimed to isolate the effect of emotional vocalization from the linguistic content by using fearful screams which are emotional vocal expressions that accompany sudden fear. We aimed to examine the brain activations associated with a composite stimulus in which fearful faces and fearful screams were presented simultaneously.

METHOD

Sample: Ten adult right handed college educated normal volunteers, 6 of them female, with a mean age of 23 years, SD of 1.9 and mean education of 20 years of schooling with S.D. of 1.95, volunteered for the study. Informed consent was taken as per the requirements of the Ethics Committee of NIMHANS.

Task : Audio-visual inputs of fear formed the stimuli. The visual component consisted of photographs of 40 faces (25 Male and 15 female) expressing intense fear. Forty different theatre actors of Indian origin were photographed as they depicted a facial expression of intense fear. The color photographs were converted to a grayscale image to fit into a 440 X 580 pixel window. These 40 faces were shown to 10 judges (young normal adults) who were asked to recognize the emotion depicted. 35 of the faces were reported to depict intense fear by all the judges. As 40 faces were required as stimuli for active blocks, 5 faces were repeated. The repetition occurred atleast 2 blocks apart. The audio component of the stimuli consisted of 10 male and 9 female vocalizations of fear which were high pitched screams. These were variations of the Hollywood 'Wilhelm Scream' acquired under a Creative Commons Sharealike Licence (from Freesound.org). The screams were preprocessed to a standard level of stereo amplification (-3db). The screams started with a high pitch and ebbed towards the end. Each photograph was coupled with a scream. Repetitions of screams occurred only after at least five intervening screams to make up the total of 40 screams required to couple with 40 fearful faces. Male faces were coupled with male screams and female faces with female screams to form the 40 stimuli. The scream started 200 milliseconds after the photograph appeared. The average duration of the screams was 1.2 seconds with a S.D. of 0.45 seconds. The order of stimuli was randomized.

fMRI Paradigm: A block design paradigm consisting of 10 active and 10 rest blocks alternating 4 times totaling to 80 dynamics was used. Emotional stimuli were presented in the active blocks and a cross hair in the rest blocks. Volunteers were asked to focus on the faces as the screams would be heard in any case.

fMRI Acquisition: MRI scanning was conducted using a 3 Tesla Siemens Magnetom Skyra scanner. Anatomical images were obtained with T1 MPRAGE sequence. The FOV was 240 mm, slice thickness was 0.9mm and the number of slices per slab was 176, voxel size was 0.9*0.9*0.9mm. fMRI was acquired with EPI sequence in which TR was 3 secs, TE .03 secs, 80 dynamics with FOV of 192mm, slice thickness 4mm, number of slices 36, voxel size 3*3*4mm and the matrix 64*64.

fMRI Analysis: Statistical parametric Mapping (SPM 8) was used for fMRI analysis. The fMRI data pre-processing consisted of realignment to correct motion artifacts(maintained below 3 mm), normalization to fit the EPI template of MNI and Smoothing to arrive at 8mmx8mmx8mm voxel.1st level analysis for individual subjects and the 2nd level group analysis was done with threshold of $p < 0.001$ and a voxel cluster size of 5

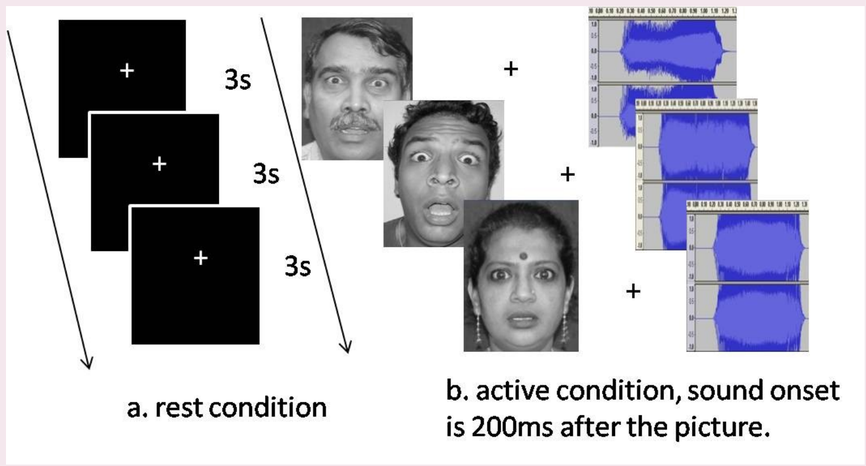
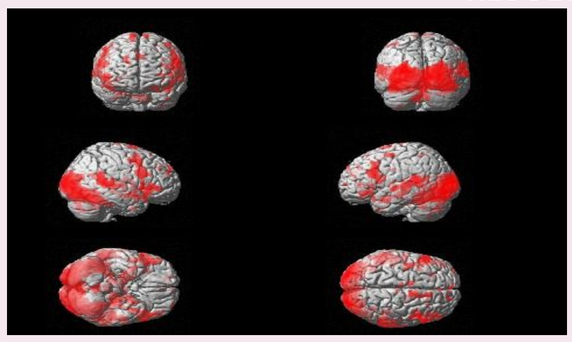


Figure 1. Paradigm Design

RESULTS



TEMPORAL LOBE

Brain Region	LEFT	RIGHT
STG	BA 38	BA 22
MTG	BA 21	BA 38
IFG		BA 13

PARIETAL LOBE

Brain Region	LEFT	RIGHT
SPL	BA 7	
IPL	BA 40	

OCCIPITAL LOBE

Brain Region	LEFT	RIGHT
Lingual G		BA 17 , BA 18
IOG	BA 18	
MTG	BA 19	

LIMBIC LOBE

Brain Region	LEFT	RIGHT
Parahippocampal Gyrus	BA 28 BA 34	BA 28 Amygdala
Cingulate Gyrus		BA 24

FRONTAL LOBE

Brain region	LEFT	RIGHT
Superiror FG	BA 6, BA 10	BA 6 , BA 8
Middle FG	BA 9 , BA 8 , BA 10 ,BA 6	
Inferior FG	BA 47 BA 46	BA 9 BA 13
Medial FG	BA 8	BA 8 BA 9
Precentral G	BA 6 , BA 4, BA 44	
Paracentral Lobule		BA 6

SUB-LOBAR

Brain Region	LEFT	RIGHT
Thalamus	Ventral lateral Nucleus	Ventral Posterior Lateral Nucleus
Caudate		Caudate Body
Lentiform Nucleus	Putamen	Putamen
Insula	BA 13	
Claustrum		Claustrum
Mid Brain		Right Substantia Nigra

DISCUSSION

Forming the Integrated Percept: Bilateral Occipital activations in Striate (BA 17) & extra striate regions (BA18 & BA19) is attributed to the visual stimulus. Visual attention is recruited as seen in the activation of left precuneus (BA7). Right superior temporal gyrus (BA 22) activations have mediated processing of pitch, loudness and prosody of scream. Activation of right Claustrum indicates the cross modal integration of the visual and auditory stimuli. Claustrum mediates intermodal integration and timing (Crick & Koch, 2005). Activations of bilateral temporal pole (BA 38) suggests the binding of the integrated percept to the visceral responses of fear. Temporal pole binds highly processed perceptual inputs to visceral emotional responses (Ding, et. al., 2009).

Evocation of Fear: Activations of right amygdala and left insula indicates perception of fear. Left middle temporal gyrus activation could be the processing of movement in the face while depicting fear. Even in the absence of linguistic stimuli, activation of left inferior parietal lobule may signify expectation of meaningful utterances after the scream. Activations of the parahippocampal gyrus, i.e. bilateral BA 28 and left BA 34 are related to activation of episodic memories. Activations in the primary motor and pre-motor regions of BA 4, BA 6 and BA 44, is attributed to motor responses due to experiencing fear.

***Regulation of Fear*:** Activations of dorsolateral prefrontal cortex (bilateral BA 9 & left 46) which mediates working memory & regulation of effort could be regulating the function of the orbito frontal cortex (left BA 10) as seen by the activations in this area. The activations in the basal ganglia (Right caudate body, bilateral putamen, right substantia nigra), as well as ventral lateral nucleus of bilateral thalami indicate the activation of the orbitofrontal -striatal fronto striatal network. The orbitofrontal cortex appears to be regulated by the dorsolateral prefrontal cortex and the orbitofrontal -striatal network. A further center for inhibitory control which is activated is Right anterior cingulate gyrus (BA 24).

CONCLUSIONS

The fearful audio visual stimuli is combined into an integrated percept which is then bound to visceral emotional responses. The fear evoked is regulated by cognitive processes and inhibitory control.

ACKNOWLEDGEMENT:

We thank,

-The Department of Science and Technology (DST), Government of India for funding this research

-Dr Senthil Kumaran, Associate Professor, Department of NMR, AIIMS , New Delhi for guidance in SPM analysis

REFERENCES :

Alexander, G. E., M.R. DeLong, P.L. Strick, Parallel organization of functionally segregated circuits linking basal ganglia and cortex, Annu. Rev.Neurosci. 9 (1986) 357 381.

Allman, M, Atiya Hakeem, Joseph M. Erwin, Esther Nimchinsky, Patrick Hof The Anterior Cingulate CortexThe Evolution of an Interface between Emotion and Cognition:Annals of the New York Academy of Sciences (2006) Volume 935 Pages 107 – 177

Corinna Klinge, Brigitte Roder and Christian Buchel (2010) : Increased amygdala activation to emotional auditory stimuli in the blind. *Brain 2010: 133; 1729–1736*

Crick FC, Koch C (2005) What is the function of the claustrum? Philos Trans R Soc Lond B Biol Sci 360:1271–127

de Gelder B, Vroomen J (2000): The perception of emotions by ear and eye. Cognit Emotion 14:289–311.

Ding SL, Van Hoesen GW, Cassell MD, Poremba A. (2009). Parcellation of human temporal polar cortex: A combined analysis of multiple cytoarchitectonic, chemoarchitectonic, and pathological markers. J Comp Neurol. 18;514(6):595-623.PubMed

Ekamn, P & Frieson, W.V. (1976) : Measuring Facial Movement. Journal of Environmental Psychology and Nonverbal Behaviour , 1, 56-75.

Ethofer T, Silke Anders, Michael Erb, Christina Droll, Lydia Royen, Ralf Saur, Susanne Reiterer, Wolfgang Grodd and Dirk Wildgrube (2006) ,Impact of Voice on Emotional Judgment of Faces:An Event-Related fMRI Study, Wiley Interscience

Massaro, D.W., & Egan, P.B. (1996). Perceiving affect from the voice and the face.

Psychological Bulletin and Review, 3, 215-221