

# Atypical auditory-visual integration mechanism in Borderline Personality Disorder: A fMRI analysis using emotional congruence and incongruence in music and facial images

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**Introduction:** Borderline personality disorder (BPD) is a prevalent mental illness characterized by pervasive instability in emotion, interpersonal relationships, self-image, and behavior [1]. The hallmark features of BPD are affective instability and severe mood swings [2] but there have been few functional imaging studies to investigate neuronal substrates underlying these features in BPD patients. Our previous fMRI study reported that there were significant Blood Oxygen Level Dependent (BOLD) signal increases in the superior temporal gyrus (STG) and fusiform gyrus (FG) of healthy young adults, which respond to emotionally congruent and incongruent music-face images, respectively [3]. We presume that these BOLD gains in STG and FG underlie emotion perception that responds to emotional congruence in multi-modal sensory inputs. This study extends our fMRI technique to examine how STG and FG of BPD patients respond to emotionally paired music-face images, which might provide a mechanism related to elevated response to emotional stimuli. **Materials and Methods:** Six healthy volunteers (age 23±2.7 years, all females) and five BPD patients (age 25.8±3.3 years, all females) participated in this study. The experiment was conducted in the context of a conventional block-design experiment consisting of music alone [30 second excerpt of happy music (HM), or sad music (SM)], face alone [30 second presentation of 10 happy face images at 3 second intervals for happy face (HF), or 30 second presentation of 10 sad face images at 3 second intervals for sad face (SF)], and music combined with faces where the music excerpt was played while presenting either congruent emotional faces ["HM+HF", "SM+SF"] or incongruent emotional faces ["HM+SF", "SM+HF"]. A fixation cross was presented for the OFF condition between every emotion stimulus. fMRI experiments were conducted on a 3-T GE Signa MR equipped with an 8-channel ASSET head coil at TR = 3000ms, TE = 35ms, flip angle = 90°, field of view = 240 mm, matrix size = 64x64, slice thickness = 4 mm, and zero gap covering whole brain. The 336 functional time series was realigned, normalized into a standard stereotaxic space using the MNI EPI template, and smoothed using an 8-mm FWHM Gaussian kernel filter. The eight experimental conditions, (HM, HF, "HM+HF", "HM+SF", SM, SF, "SM+SF", "SM+HF") were modeled with a box-car function convolved with a hemodynamic function using the SPM general linear model. The first-level analysis identified activation in individual subjects corresponding to the following main effects of interest: a) STG BOLD gains from emotional congruence: "HM+HF">HF and "SM+SF">SF, b) FG BOLD gain from emotional incongruence: "HM+HF">HM and "SM+SF">SM. Each contrast image of all four effects of interest was combined with the second level analysis using a one-sample t-test to determine group averaged activations. For each effect of interest, the number of voxels activated at uncorrected p < 0.001 in bilateral STG and FG was assumed as corresponding BOLD gain. Subsequent to the imaging study, the subjects underwent behavioral testing to assess their ratings for emotion of the music and face stimuli. For music trials, each musical excerpt was presented for 30 seconds through earphones. The subjects were instructed to rate the emotion on a scale of -7 (saddest) to +7 (happiest) after listening to entire musical excerpt. For face trials, each face was displayed for 3 seconds on a computer screen. Faces were presented either alone or together with each of the musical excerpts. In order to determine whether emotion perception was enhanced or diminished by combining emotionally congruent and incongruent multi-modal sensory inputs, ratings for single modality alone were subtracted from ratings of combined modalities for each subject as follows: a) perception rate-shift from emotional congruence: a) "HM+HF"-HF and "SM+SF"-SF, b) perception rate-shift from emotional incongruence: "HM+SF"-HM and "SM+HF"-SM. These rate-shifts were finally correlated with corresponding BOLD gains in STG and FG in order to demonstrate the reliability of fMRI findings. **Results and Discussion:** Significant BOLD activations were found in bilateral STG and FG of normal controls that respond to

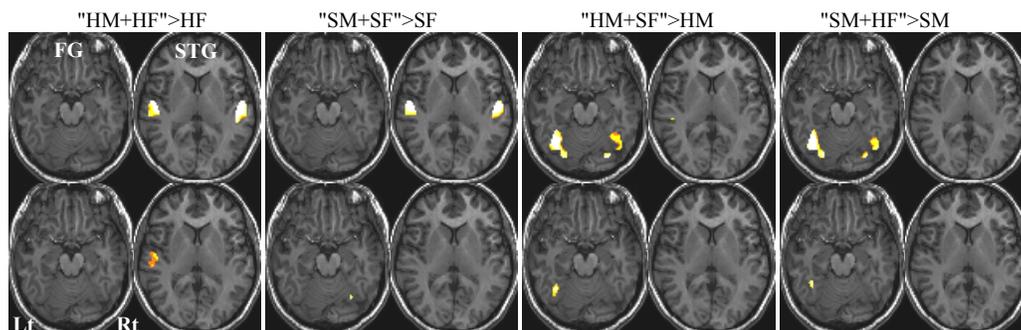


Figure 1: BOLD gains at STG and FG responding to emotional congruent and incongruent music and face images. (top) normal controls, n=6 (bottom) BPD patients, n=5. uncorrected p < 0.001 and extent > 10.

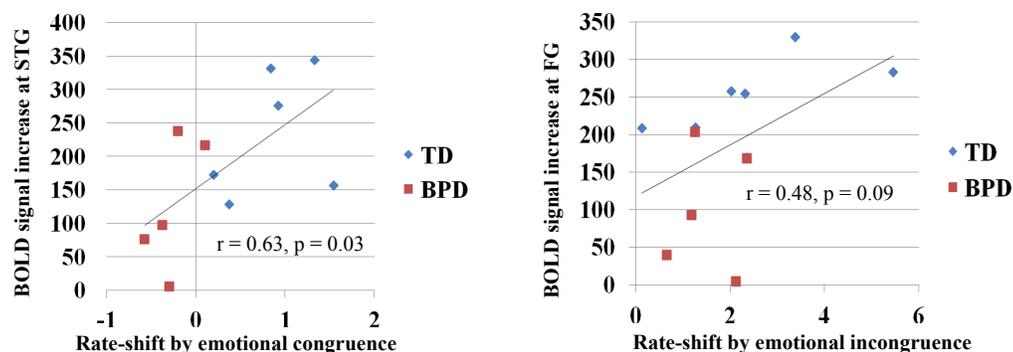


Figure 2: Correlation between BOLD signal increase and behavioral assessment. (left) STG and (right)

emotionally congruent and incongruent conditions while BPD patients showed significantly reduced BOLD signals in bilateral STG and FG for emotional congruence and incongruence (Fig. 1). Behavioral testing supplemented these findings by showing that subject ratings of emotion in faces were modulated by the emotion conveyed by the music. In normal controls, emotional congruence across modalities enhances the perception of auditory emotion in STG while incongruence appears to facilitate the perception of visual emotion in FG, leading to increased BOLD signals in STG and FG, respectively (Fig. 2). However, BPD patients did not show both increased rate-shifts and BOLD signal increases in STG and FG, suggesting an impaired regulatory mechanism to integrate emotion perception. It might be used as a biomarker for BPD. **Reference:** [1] Swartz et al. J Personal Disord, 1990. [2] Trull TJ et al., Clin Psychol Rev. 2000. [3] Jeong et al. Neuroimage, 2011.