Alterations in neural network activity of methamphetamine abusers performing an emotion matching task: fMRI study

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Introduction

Methamphetamine (MA) abusers often exhibit socially problematic behaviors such as diminished empathy, decreased emotional regulation, and interpersonal violence, which may be attributable to alterations in emotional perception[1]. However, few studies have used functional magnetic resonance imaging (fMRI) to directly examine perceptual processing of threatening or fearful non-face images in methamphetamine abusers. Therefore, the aim of this study is to investigate the difference in neural correlates of negative emotion processing between MA abusers and healthy subjects using a small subset of complex visual scenes depicting fear or threat, derived from International Affective Picture System.

Subject and Methods

Subjects: Nineteen abstinent MA abusers and 19 healthy subjects participated in this study. All MA abusers were recruited by two licensed psychiatrists from the Drug Abuse Center, Bugok National Hospital, Korea, based on consensus diagnoses according to DSM-IV criteria. Healthy subjects from towns neighboring Kyungpook National University Hospital were recruited as volunteers. To control for gender bias, all subjects (both MA abusers and control subjects) were male. The ages of the MA abusers ranged from 31 to 52 years (mean, 36.06 years) and those of the control subjects ranged from 33 to 42 years (mean, 37.05 years). After detailed explanation of the study design and potential risks, all subjects gave written informed consent. All study protocols were approved by the local Internal Review Board (IRB).

Functional MRI: The fMRI task paradigm was used emotional pain task with block design. Functional magnetic resonance images were acquired using a 3.0T GE HD scanner(EPI, TR=3000ms, TE=40ms, matrix=64x64, Thickness=3.0mm, FOV=192mm, no gap). Anatomical images were acquired using 3D-FSPGR sequence(TR=7.8ms, TE=3ms, matrix=256x256, no gap).

Fearful matching paradigm: While undergoing fMRI, subjects performed a visual matching task, adapted from Hariri et al. (2003), consisting of two types of trials: emotion matching and shape matching (Fig. 1). During emotion match trials, the target stimuli were 12 different images from IAPS: 6 representing fear or threats of natural origin (i.e., dogs, sharks, snakes, spiders) and 6 threats of artificial origin (i.e., guns, car accidents, plane crashes, explosions). During shape match trials, we used simple geometric shapes (circles, and vertical and horizontal ellipses) as control stimuli. In each trial, the subjects were asked to match a target stimulus to one of two choice stimuli. Each trial began with the presentation of a target item centered in the upper portion of the visual field, and two choice items (one matching the target) presented in the lower right and left portions of the visual field. Stimuli consisted of four experimental blocks: two blocks each of "match" and "control," each lasting for 36 s, for a total scan time of 2 min 24 s.

Data Analysis: Statistical parametric map software (SPM5, Wellcome Department of Cognitive Neurology, London, UK) was used to generate activation map. One-sample for within group analysis with voxel-wise intensity threshold of $p<0.05$ (FDR, corrected) and two-sample t-test for between group analysis were performed with small volume corrected for multiple comparisons across the whole brain at a level of $p < 0.05$.

Result and Discussion

In within-group analyses, healthy subjects and MA abusers activated a similarly distributed cortical network, prominently including amygdala, fusiform gyrus (FG), parahippocampa gyrus (PG), posterior cingulate cortex (PCC), insula, dorsal anterior cingulate cortex (dACC), temporoparietal junction (TPJ), ventrolateral prefrontal cortex (VLPFC), and inferior frontal cortex (IFG)(Fig.2). In between-group analysis, however, MA abusers showed reduced activation in both insula and increased activation in FG, PG, and PCC relative to MA abusers(Fig. 3.(a)). Hypoactivation of the insula in MA abusers relative to healthy subjects suggests that the ability of emotional awareness to threatening scenes[2] and empathy for another's pain could be compromised in MA abusers. Hyperactivity in the FG, PG, and PCC in MA abusers relative to healthy subjects(Fig. 3.(b)) indicates that threatening and fearful images from the IAPS may remind MA abusers of episodic memory related to antisocial behaviors towards others[3]. Therefore, functional impairment of these neural networks in MA abuse may contribute to altered perception of fearful scene, which could lead to diminish empathy and increase risk to aggressive behavior.

References

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Result data

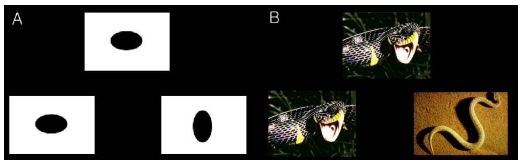


Fig 1. Sample pictures of shape match(A) trial and fearful match trial(B).

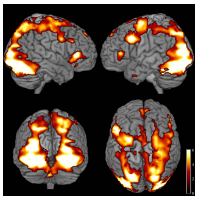
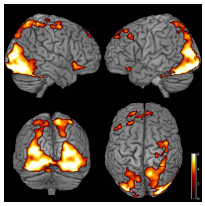

(a)

(b)

Fig 2. Healthy subjects(a) and MA abusers(b) activated a cortical network, prominently including amygdala, FG, PG, PCC, insula, dACC, TPJ, VLPFC, and IFG. ($p<0.05$, FDR corrected)

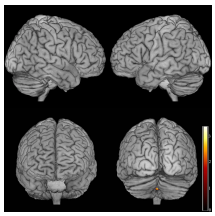
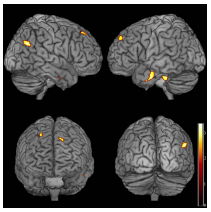

(a)

(b)

Fig 3. MA abusers showed reduced activation in both insula and increased activation in FG, PG, and PCC relative to MA abusers (a) and hyperactivity in the FG, PG, and PCC in MA abusers relative to healthy subjects(b)($p<0.05$, SVC, FDR corrected)