

Alcohol Intoxication Effects On A Visual Perception Task: An fMRI Study

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Synopsis

We studied the effects of two doses of alcohol on the neural correlates of a visual perception task. Analysis revealed robust activation in visual/visual association areas, frontal eye field/dorsolateral prefrontal cortex (DLPFC) and the supplemental motor area. EtOH resulted in a dose dependent activation amplitude decrease over much (but not all) of the visual perception network and resulted in a decrease in the maximum contrast-to-noise-ratio. Significant dose-dependent increases were observed in insula, DLPFC, and precentral regions whereas dose-dependent decreases were observed in cingulate, precuneus, and middle frontal areas. Alcohol thus appears to have both global and local effects.

Introduction

The Motor-Free Visual Perception Task, Revised (MVPT-R) [1] provides measures of overall visual perceptual processing ability. It involves different cognitive elements, including visual discrimination, mental rotation and spatial relationships. We used the MVPT-R to study brain activation patterns in normal individuals sober and at two doses of alcohol intoxication with event-related fMRI. The MVPT-R has been employed previously as a predictor of driving ability due to the following characteristics: (a) relevance to highway safety, (b) relation to on-the-road driving behavior or crashes, (c) capability of assessment on a driving simulator, (d) sensitivity to ETOH effects [2]. As part of a larger study on simulated driving, we've recently adopted the MVPT-R to an event-related fMRI paradigm and demonstrated robust activation in ten healthy participants in visual and visual association areas as well as frontal eye field areas/dorsolateral prefrontal cortex (FEF/DLPFC) and the supplemental motor area (SMA) [3].

Methods

Study participants were 10 screened healthy men (N = 6) and women, aged 24.2 ± 5.8 , with drivers licenses and good driving records. Each subject received a dose of beverage alcohol individualized to subject gender and body mass index, calculated using a published algorithm and administered in a single-blind standardized fashion, designed to produce blood alcohol content (BAC) of 0.05 or 0.10, and placebo. BAC's were determined immediately before and after the scan session, using a hand-held meter. Subjects began their test sessions 15 minutes post beverage. The functional protocol consisted of a 5 minute gradient echo planar T2*-weighted scan (FOV=24, TR=1s, TE=39ms, slice thickness=5mm, number of slices=18) acquired parallel to the AC-PC line. SPM99 was used to contrast task-correlated activations across ETOH doses. Both fixed and random effects analysis were performed to examine the correlation of the MVPT-R task with fMRI signal. In order to examine the data for dose related effects a third analysis was performed comparing the amplitude difference between the sober (S) and drug (D) conditions for the high (H) dose with the amplitude difference between the sober and intoxicated conditions for the low (L) dose, that is ($\Delta_{H+L} [S-D]$). We also performed a similar analysis using the participant's own BAC levels. Additionally, an ROI analysis of specific nodes in the activated network (bilateral frontal eye fields (FEF), primary and association visual areas, supplemental motor areas, cerebellum and insula) was performed to examine dose dependent amplitude changes.

Results

All subjects performed within 5% of the task norm at baseline. We explored the effect of ETOH at two BAC's on MVPT-R task performance. At the lower BAC (mean 0.041 ± 0.016), on 5-point analog scale, subjects indicated subjective intoxication of 1.0 ± 0.7 and at the higher BAC (mean 0.096 ± 0.04), subjects self-rated intoxication of 3.1 ± 0.8 . Participants receiving the low dose of alcohol tended ($p < 0.07$) towards slightly decreased reaction time whereas participants receiving the high dose of alcohol slightly ($p < 0.08$) increased in reaction time. This is consistent with performance measures on a simulated driving task in which low-dose recipients indicated an awareness of their intoxication and an attempt to compensate [4]. The high-dose increased reaction time, but unimpaired accuracy are consistent with a study showing impairments in speed and efficiency but not accuracy of timing in a variety of motor performance measures [5].

With regard to alcohol-free task-related brain activation, as previously reported [3], SPM group analysis revealed robust activation in visual and visual association areas, FEF/dorsolateral prefrontal cortex (DLPFC) and the supplemental motor area (SMA). Consistent with a previous study of EtOH and visual stimulation, EtOH resulted in a dose dependent decrease in activation amplitude over much (but not all) of the visual perception network.

We observed both global and local hemodynamic effects of alcohol. There was a global signal decrease evident both by visual inspection of Figure 1 and by examination of the maximum *t*-values (sober=13.64, low dose=11.49, high dose=7.56). In addition to the global effects, there were also localized increases and decreases. In particular, the CNR in frontal regions increased (relative to sober) at the low dose and decreased (relative to sober) in the high dose. The dose correlation analysis (not shown) revealed dose-dependent decreases in bilateral parietal visual areas such as precuneus and also in bilateral areas which appear to be visual area MT. Dose dependent increases in bilateral insular regions. Some areas (FEF/DLPFC/SMA) became more diffusely activated (i.e. increased in spatial extent) at the highest dose.

Conclusion

To summarize, we examined the neural correlates of a driving related visual perception task. Significant dose-dependent increases were observed in insula, DLPFC, and precentral regions whereas dose-dependent decreases were observed in anterior and posterior cingulate, precuneus, and middle frontal areas. Some areas (FEF/DLPFC/SMA) became more diffusely activated (i.e. increased in spatial extent) at the highest dose. Alcohol thus appears to have both global and local effects upon the neural correlates of the MVPT-R task, some of which are dose dependent.

References

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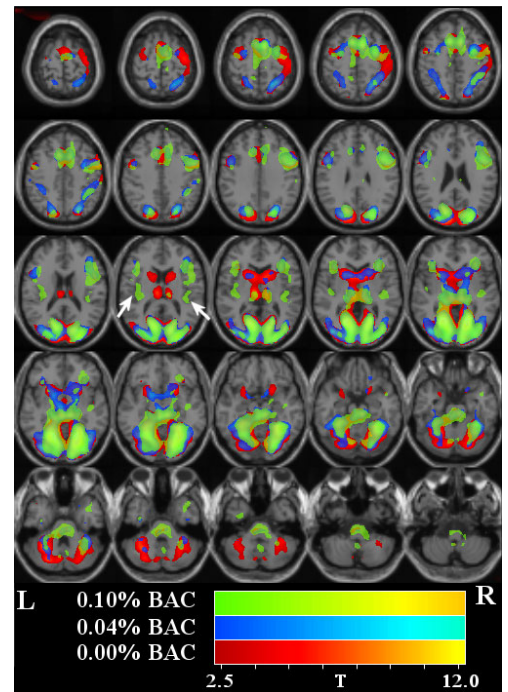


Figure 1: Main effect group maps for (mean) sober, low dose, and high dose conditions. *T*-maps are displayed over one of the normalized EPI images. Images were thresholded at $p < 0.05$ (corrected for multiple comparisons). The main effect SPM group analysis for 1) (mean) sober (colored red/orange), 2) low dose (colored blue/cyan), and 3) high dose (colored green/yellow) are displayed on the same image for clarity. It is clear that alcohol dose results in a global decrease in contrast-to-noise and also that there are some localized increases and decreases.