

Neural Dynamics of Alcohol Effects on Cognitive Control

Marinković K., Azma, S.

MGH/MIT/HMS Athinoula A. Martinos Center for Biomedical Imaging, Charlestown, MA;
Harvard Medical School Radiology Dept., Massachusetts General Hospital, Boston, MA;

367.16

INTRODUCTION

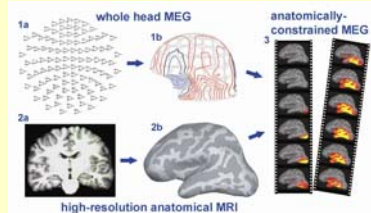
Alcohol intoxication impairs executive functioning by interfering with volitional planning, the ability to evaluate competing demands of a task, inhibit maladaptive responses, and execute cognitive control. The purpose of this study was to identify effects of moderate alcohol intoxication on temporal (“when”) and spatial (“where”) characteristics of distributed neural systems underlying these processes during Stroop task [1], with anatomically-constrained MEG method (aMEG).

METHODS

Healthy subjects (N=18, 8 women) participated in placebo and alcohol conditions (0.6g/kg for men, 0.55 g/kg women). A modified Stroop task combined reading and color naming and used manual responses. The conditions were:
-Incongruent BLUE (16% trials) – name color
-Congruent BLUE (16% trials) – name color
-Neutral PAID (16% trials) – name color
-Read BLUE (52% trials) – read color
Four colors were used as stimuli and mapped onto 4 button presses (red, green in left hand and blue, yellow in right hand). The task was to press a button corresponding to the font color, or to the word meaning when written in gray.
Stimuli (576 total) were presented for 300 ms every 2 sec.

Anatomically-constrained MEG (aMEG):

MEG signals were recorded with a whole-head 306 channel Neuromag instrument (Elekta) and here presented as waveforms (1a) or magnetic fields (1b). Based on high-resolution anatomical MRI (2a) each person’s cortical surface was reconstructed (2b) in order to constrain a noise-normalized minimum norm inverse solution (3), and to obtain a group average by aligning cortical folding patterns. Group average dynamic statistical parametric maps (dSPMs) are presented (2) (<http://www.nmr.mgh.harvard.edu/meg/>).

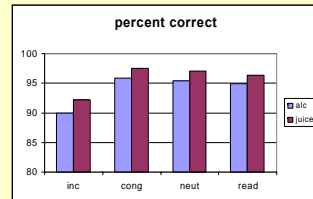


Two structural scans were obtained for each person (3T Siemens Allegra, TR=2530, TE=3.25, 128 slices at 1.33 mm) and analyzed with FreeSurfer.

BEHAVIORAL RESULTS

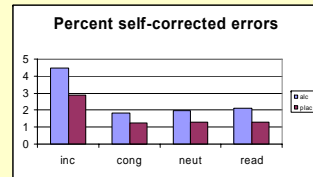
Behavioral results (N=18, 8 females)

- strong Stroop color-word interference effect is reflected in lower accuracy and longer RTs on incongruent as compared to other conditions
-no effect of gender was observed on any measure



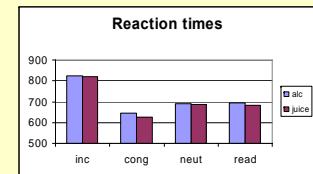
Response accuracy

- lower on incongruent trials
- lower under alcohol overall



Error-correction

(% of trials on which subjects corrected their responses – “oops” - response)
- significantly higher on incongruent trials
- and under alcohol condition (strong trend)



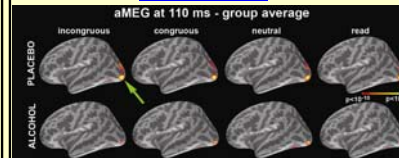
Reaction times

- longer on incongruent trials
- not affected by alcohol

aMEG RESULTS

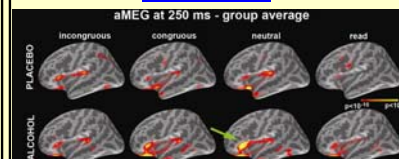
Group average aMEG activity (N=9) estimated at 110, 250, 400 and 600 ms.

aMEG 110 ms



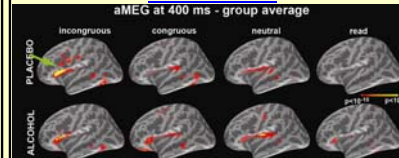
Alcohol attenuated the early sensory processing at ~110 ms (⇨), confirming and extending our previous findings [3]

aMEG 250 ms



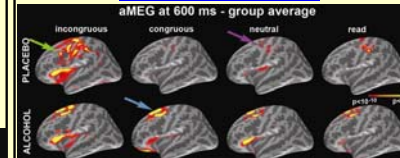
Alcohol increased activity estimated to the left anterior inferior prefrontal cortex (LAIPC) on neutral trials (⇨). This may reflect alcohol-induced difficulty in semantic and contextual integration, in agreement with our previous observations [3, 4].

aMEG 400 ms



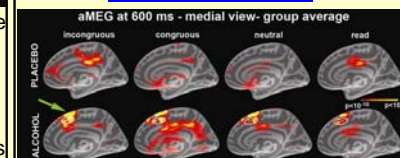
In contrast to alcohol, LAIPC and left dorsolateral cortex distributed were selectively activated in INC trials under placebo (⇨) indicating their involvement in detecting stimulus incongruity and preparation for response execution

aMEG 600 ms - lateral



Activity in motor and premotor areas evoked by congruous, neutral, and read trials in placebo condition (⇨) indicates optimized motor planning/execution under low-conflict. In contrast, activity in distributed prefrontal regions (⇨) may indicate response optimization under high-conflict. Alcohol reduced the prefrontal activity and increased activity in the supplementary motor area in all conditions (⇨). This alcohol-induced impairment and network alteration may underlie behavioral deficits.

aMEG 600 ms - medial



Dorsal anterior cingulate activity was evoked in the alcohol condition on all trial types (white circles), along with the sustained SMA and pre-SMA contributions (⇨), suggesting increased effort in response preparation and execution due to inebriation.

The excellent temporal resolution of aMEG suggests that the ACC is not activated by conflict detection [5], but contributes to response execution and performance monitoring.

CONCLUSIONS

- In the Stroop task alcohol increased errors and increased self-corrections on incongruent trials (“oops” responses)
- alcohol attenuated early sensory processing (110ms)
- alcohol increased difficulty in semantic and contextual integration
- alcohol impaired response optimization under high-conflict and increased reliance on the SMA and dorsal ACC
-dACC engaged during response execution and monitoring, not during conflict detection

REFERENCES

- MacLeod CM (1991) Half a century of research on the Stroop effect: an integrative review. *Psychol Bull* 109(2):163-203.
- Dale et al.(2000). Dynamic statistical parametric mapping: Combining fMRI and MEG for high-resolution imaging of cortical activity. *Neuron* 26:55-67.
- Marinkovic et al. (2004). Effects of alcohol on verbal processing: Event-related potential study. *Alc. Clin. Exp. Res.* 28:415-423.
- Marinkovic. (2004). Spatiotemporal dynamics of word processing in the human cortex. *Neuroscientist*. 10:142-152.
- Carter CS et al (1998) Anterior cingulate cortex, error detection, and the online monitoring of performance. *Science* 280(5364): 747-9.

We are grateful to Justine Wang, Zainab Azeez, Matti Hämmäläinen, Anders Dale, Eric Halgren, Marlene Oscar-Berman and Bruce Rosen

This work was supported by ABMRF, K01 AA13402, NCRR (P41RR14075) and the MIND Institute.

For more information email:
xenia@nmr.mgh.harvard.edu

