Reduced Cortical Gray Matter in Long-Term Abstinent Alcoholics

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Background

The harmful effects of alcohol dependence on the structure and function of the human brain have been well documented. However, there is an increasing body of evidence suggesting that the detrimental cognitive effects caused by alcohol can be at least partially reversed with long-term abstinence. We have previously shown that alcoholics with sufficiently long periods of abstinence do not exhibit cognitive deficiencies in many of the areas associated with alcoholism, with the notable exception of the spatial processing domain[1]. Cortical gray matter can be divided into different regions based on function using the Talairach atlas, from which region of interest masks can be created for volumetric measurements. Although application of atlas-based regions of interest (ROIs) is a common method for performing tissue volumetry in MRI, accurately delineating the cortical sheet in the requisite area is not a simple matter because of the wide variation in cortical infolding. We have developed and applied a technique that corrects for many of the shortcomings of the conventional method of volumetry and applied it to a set of middle-aged long-term abstinent alcoholics and non-alcoholic controls.

Methods

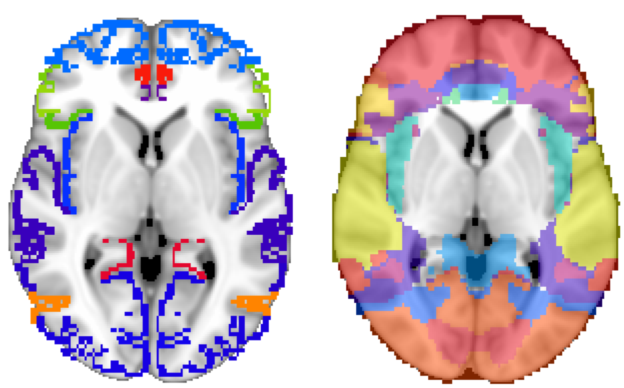
The study cohort consisted of 52 middle-aged long-term abstinent alcoholics ranging in age from 35 to 58 years, and 48 non-alcoholic controls, ranging from 34 to 60 years old. All subjects underwent psychological and cognitive testing and T1-weighted MR imaging of the brain. Processing of the images involved (1) skull and non-brain matter removal, (2) tissue segmentation, (3) correcting misclassified white matter due to white matter signal hyperintensities (WMSH), (4) linear registration of the MNI152 average brain to each subject's T1 image, (5) application of the ROI masks to the cortical gray matter, and (6) applying a sulcal/gyral correction algorithm. The ROI masks were created in MNI space using a nearest neighbor interpolation to increase the thickness of the ROIs while avoiding overlap with adjacent regions. An automated WMSH delineation algorithm that we developed was used to reclassify as white matter areas affected by WMSH, which are usually misclassified as gray matter in the segmentation step. The sulcal/gyral correction was then used to re-include gyral folds that may have been clipped by registration inaccuracies and exclude parts of neighboring gyri that may have been wrongly included.

Results

After removing variability in gray matter volumes due to variation in head size and age, we found significantly reduced gray matter volumes in LTAA compared to NAC (6.9% and 6.2% in the parietal and occipital lobes). Analysis of the sub-lobar regions revealed less gray matter in LTAA in the primary sensory cortex (frontal lobe), anterior cingulate (limbic lobe), lateral parietal (parietal lobe), and visual association cortex (occipital lobe). There were no significant associations between regional gray matter tissue volumes and alcohol use variables including length of abstinence within the LTAA.

Conclusion

Our findings of reduced volumes in the visual association and lateral parietal areas are consistent with our previous findings of spatial processing deficits in these LTAA despite normal performance in other domains. Our finding of comparable cortical gray matter in prefrontal and temporal lobes in LTAA vs. NAC is consistent with our finding of intact executive function and memory in these LTAA. Within the LTAA, we did not find any significant relationships between ROI volumes and length of abstinence (ranging from 6 months to 21 years). This agrees with a recent study[2], suggesting that tissue volume recovery may be asymptotic in recovering alcoholics, with the fastest recovery rates occurring shortly after abstinence.



Left: Brodmann areas in MNI space, overlaid on the standard brain. Notice how a significant amount of the cortical gray matter is not captured under the mask. **Right:** Our regions of interest, created using combinations of nearby Brodmann areas after a nearest neighbor interpolation. A vast majority of cortical gray matter is included under these masks.

References

1. Fein G., McGillivray S. *Cognitive performance in long-term abstinent elderly alcoholics.* Alcohol Clin Exp Res. 31(11):1788-1799.

2. Cardenas V.A., Studholme C., Gazdzinski S., Durazzo T.C., Meyerhoff, D. *Deformation-based morphometry of brain changes in alcoholc dependence and abstinence.* Neuroimage. 34:879-887.