Visualizing anterior temporal activation during semantic processing with parallel imaging techniques

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Introduction

fMRI has become the standard tool for the visualization of brain activation during various cognitive tasks. It has several advantages compared to PET experiments such as a better spatial and temporal resolution and non-invasiveness which makes it possible to perform repeated measurements in the same subject. Many studies have been performed using these BOLD fMRI techniques replicating earlier PET studies and showing similar results for sensory and higher order cognitive functions[1]. On the other hand several fMRI studies have been unable to replicate the PET results of some other cognitive functions[2]. The major contribution to this failure was the large degradation in the BOLD EPI fMRI images, where the activated areas in the PET studies had been found. The fMRI image quality loss in those areas is a result of large susceptibility artifacts near tissue boundaries at the edges of the brain and in the close vicinity of air cavities, which results in a reduction of the SNR and a drop in CNR of the potential activated brain areas. In this study we modified the fMRI acquisition protocol to reduce the effect of the susceptibility artifacts, both in the medial and anterior temporal poles of the brain by using a combination of an eight channel receive only head coil and the GRAPPA parallel imaging technique. With the aid of these techniques we replicated a previously performed PET study demonstrating left anterior temporal cortex activation during semantic processing tasks[3].

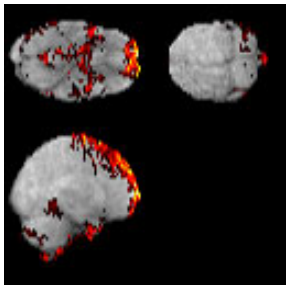
Methods

The fMRI experiments were performed on 16 right-handed healthy volunteers (20-74 yrs) in a Sonata 1.5T MR scanner (Siemens Medical, Erlangen, Germany). The sequence for the acquisition of the fMRI datasets was an FE-EPI sequence, imaging 36 sagittal adjacent slices with a voxel size of 3x3x3mm, TR/TE = 3000/40ms. The images were acquired using an 8 channel head coil array (MRI Devices Corporation WI, USA) and a GRAPPA acceleration factor of 2. In every volunteer 6 functional runs were acquired and every run consisted of 116 volume scans while the subject performed a task of picture and word recognition in a blocked design. The resulting fMRI datasets were analysed using SPM2, at the single subject and the group level. In some volunteers EPI fMRI volumes were acquired both with this imaging protocol (GRAPPA factor of 2) and with a standard imaging protocol in order to visualize the effects of the parallel imaging technique on the image quality. The difference in the resulting brain volumes were compared with each other after co-registration, by subtraction in order to visualize those areas suffering the largest signal loss due to susceptibility artifacts.

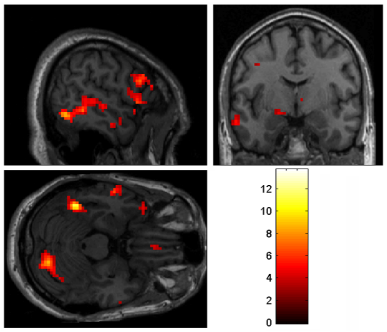
Results

Image quality and distortion measurements of the EPI volumes showed a gain of signal intensity in the medial and anterior temporal poles of the brain and also in other areas in the vicinity of air-tissue surfaces.

After group analysis of the data, the activated area showed a common semantic processing network of words and of pictures identical to that described in the original PET study. This included among others areas in the left anterior temporal cortex demonstrating the sensitivity provided by the modified acquisition protocol.



The difference between the volume acquired with GRAPPA=2 and this without GRAPPA is displayed as a color overlay on the rendered 3D volume.



Common activated areas (p_{corr}<0.05) during semantic processing of words and pictures, displaying among others activation of the anterior frontal lobe

Discussion

The advent of parallel imaging techniques makes it possible to perform cognitive fMRI studies in those areas which previously, in the standard fMRI acquisitions, suffered a lot of susceptibility artifacts and were made impossible to be visualized. This study demonstrated the ability of the fMRI technique using a GRAPPA acceleration factor of 2 to replicate a previous PET study and to find activation in the anterior temporal lobes of the brain. Due to the non-invasiveness of the fMRI technique, these experiments can now be performed in different patient populations, allowing us to perform longitudinal studies on the progression of cognitive impairment and the impact of different therapies.

References

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