Optimization of 3D EPI SENSE techniques for fMRI of highly inhomogeneous areas

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Introduction

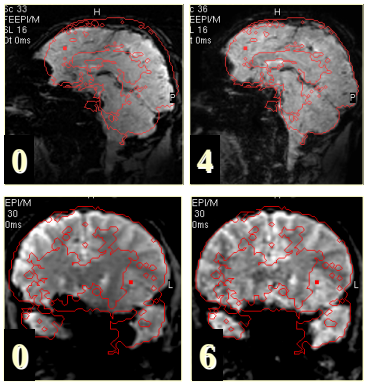
The advent of parallel imaging techniques makes it possible to perform fMRI studies in those brain areas which previously suffered from susceptibility artifacts in standard BOLD fMRI experiments[1,2]. With the trend towards higher magnetic field scanners, these susceptibility effects will become even worse. In this study we investigated the possibility of performing fMRI experiments near the olfactory regions of the human brain. These areas are located very close to the nasal cavities from which they suffer very large distortion artifacts making it virtually impossible to acquire good image quality with standard BOLD EPI sequences. At 3T this results in a complete disappearance of the orbitofrontal cortex. Therefore in fMRI experiments in these areas, the acquisition parameters have to be adapted to reduce these artifacts to a minimum. This can be achieved by maximizing the SENSE factor in the BOLD sequence, lowering the echo train readout time. In 2D EPI imaging protocols, the maximal SENSE value practically usable is limited by the number of coil elements in the phase encoding direction. When using a 3D acquisition technique, one will be able in principle to use a SENSE acceleration factor in the two different phase encoding directions, exploiting the design of the phased array coil to a maximum. In order to acquire a 3D volume of the brain in a reasonable time to perform event related studies we opted for the 3D EPI technique.

Methods

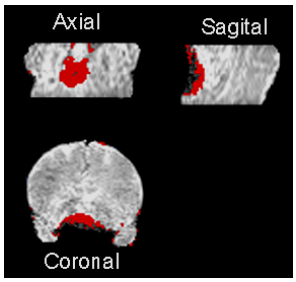
All scans were performed on a 3T Intera Scanner (Philips Medical Systems, Best, The Netherlands). The body coil was used for spin excitation and an 8 channel phased array receive only coil (MRI Devices Corporation WI, USA) was used for signal reception. The 3D EPI SENSE scans were acquired both in sagittal and transversal planes using the following acquisition parameters (TR/TE= 100/28 ms, flip angle = 25 degrees, 32 reconstructed slices, voxel size = 1.8 x 1.8 x 2.0 mm). Different SENSE acceleration factors were used to compare the resulting images for susceptibility artifacts. The SENSE factors used were: S = 0 (No-SENSE), 2, 3 ,4 for the coronal and sagittal acquisition and S=3*2=6 for the coronal acquisition only. The susceptibility artifacts were evaluated by comparing the different images with each other and with a T1 weighted 3D TFE volume.

Results

Comparison of the different 3D EPI scans shows that the 3D EPI SENSE scans with the high SENSE factors allowed the acquisition of fMRI volumes with a good image quality in the orbitofrontal cortex. As for the geometrical distortion in the EPI volumes a closer anatomical compliance with the high resolution T1 TFE images was found for an increasing SENSE factor. The different 3D EPI SENSE volumes were compared with each other by subtraction and display of the difference signal on a 3D rendered EPI volume of the brain. These rendered volumes showed a large signal gain in the anatomical areas nearby air-tissue surfaces.



The outline of the T1 3D TFE image of the brain is drawn as a red wire frame superposed on 3D EPI slices with different SENSE factors, demonstrating the dependence of the geometric distortion on the SENSE factor.



The difference between the images acquired with SENSE factor 6 and with SENSE factor 0 overlaid as a red area on the rendered brain volume

Discussion

In this study it was demonstrated that the 3D EPI SENSE technique makes it possible to perform fMRI studies in areas which suffered from very large susceptibility artifacts in classic BOLD fMRI experiments. With this technique we searched for the best acquisition parameters in order to obtain acceptable image quality in the orbitofrontal cortex to be able to perform an event related taste/smell experiment. However the loss in SNR due to the higher SENSE factors used in the sequence is a disadvantage. This loss is partly balanced by the use of the 3T static field increasing the sensitivity of the BOLD signal. It is our strong belief that it will be necessary to adapt every acquisition protocol to the area of interest. For activation in areas sensitive to susceptibility artifacts one will have to use large parallel imaging factors while for activated areas in less artifact sensitive regions one will use lower parallel imaging parameters to maximize image SNR.

References

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