Seed-based functional connectivity analysis of the emotional circuitry: Improving the signal of vulnerable regions with spin-echo EPI

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Introduction

Functional connectivity (fc) analysis allows monitoring specific regional brain changes in activation along time. By placing a seed in a region of interest (ROI) one can extract the signal variation reflecting the local activity and cross-correlate it with the whole brain voxelwise. A network map can therefore be elicited during a certain task in a selected period of time. It is a method that allows innumerous applications to further understand the cross-talk of different regions or networks. However, the signal extracted from the ROI should contain representative information of the local neural activity. The conventional gradient- (GRE) echo planar imaging (EPI) has been reported to be influenced by global vascular effects in contrast to an alternative method applying spin- (SE) EPI[1,2,3]. SE has also been suggested in the literature[4,5] as a method with improved signal quality at the inferior medial and orbitofrontal (OFC) regions. The susceptibility artifacts[4,5] commonly present during the acquisition of functional magnetic resonance imaging (fMRI) with GRE can drastically limit the investigation of the emotional circuitry. We tested the applicability of SE for whole brain functional connectivity analyses at 3T. Our general hypothesis was that the spin-EPI could offer stronger local and long range connectivity based on the improved signal stability and local spatial refinement. A posterior cingulate cortex (PCC) seed was used to address this comparison outside critical region for susceptibility artifacts. Addressing the emotional circuitry more specifically, seven seeds were used and we hypothesized that each amygdala (AMY), hippocampus (HIP), OFC, and SgACC seeds would present stronger functional connectivity maps in the comparison SE>GRE.

Methods

We selected seven ROI (fig.1) within the emotional circuitry and included the PCC for seed-based connectivity analyses to compare the MR signal from conventional GRE versus SE among 14 volunteers during resting state. The signal quality of each seed was evaluated with descriptive statistics and principal component analysis (paired t-test, $\alpha < 0.05$). Paired t-tests were used for the comparison of connectivity maps, p<0.05 family-wise error (FWE) cluster corrected.

Results

Both acquisition protocols, GRE and SE, presented consistent functional maps and the contrast SE>GRE (fig. 2 and 3) showed increased strength of functional connectivity with correction for multiple testing (p<0.05 FWE cluster corrected). The contrast GRE>SE presented no cortical suprathreshold clusters.

Fig. 1: Raw images of GE (top) and SE (bottom) and the ROIs

Discussion

To our knowledge, this was the first time that SE signal-driven fc was performed and compared with the conventional GRE. The seeds placed in the emotional circuitry presented robust and anatomically reliable[6] connectivity patterns in the differential contrast SE>GRE (fig. 2 and 3). The signal quality assessment suggested more specificity for SE signal in comparison to GRE. Extremely important regions for the emotional circuitry as the midbrain nuclei (fig. 3), generally not present in fMRI studies, were depicted in the differential contrast with correction for multiple testing. This suggests a potential benefit to be further explored in functional studies addressing the affective system. We believe that SE approaches should overcome the methodological limitations caused by susceptibility effects.
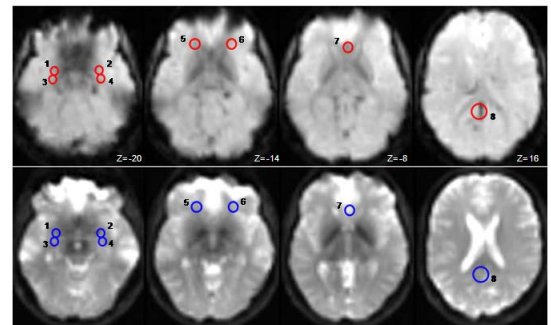
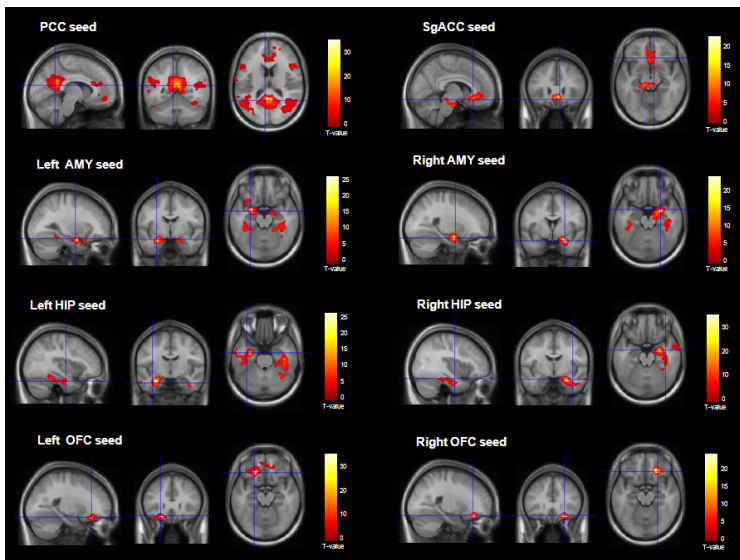

Fig. 2: Differential fc SE>GRE, paired t-tests with pFWE<0.05 cluster corrected
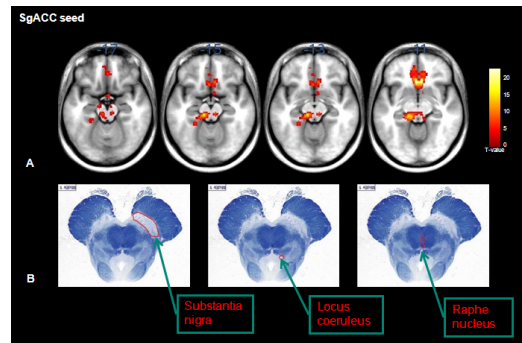

Fig. 3: (A) Differential fc SE>GRE of the SgACC seed detailing fc with midbrain structures (B) with aid of an online atlas[7]

References

[1] Buxton (2002) Cambridge University Press [2] Zhang et al (2009) NeuroImage [3] Goense et al (2008) NeuroImage [4] Schwarzbauer (2010) Neuroimage [5] Schwarzbauer and Porter (2010) Neuroimage [6] Price and Drevets (2010) Neuropsychopharmacology [7] http://isc.temple.edu/neuroanatomy/lab/atlas *published with kind permission