Functional MRI of the human amygdala avoiding susceptibility artefacts

C. Morawetz[1], C. Lange[2], P. Holz[1], J. Baudewig[1], G. Weniger[2], E. Irle[2], P. Dechent[1]

[1]MR-Research in Neurology and Psychiatry, Medical Faculty, Georg-August-University, Göttingen, Germany, [2]Department of Psychiatry and Psychotherapy, Medical Faculty, Georg-August-University, Göttingen, Germany

Introduction

fMRI is a valuable tool for neuroscience to non-invasively examine brain function. However, there are certain regions difficult to access because of their vulnerability to susceptibility artefacts. The human amygdala is one of those regions. However, as it is a core-region in the processing of emotional stimuli its characterization is especially interesting for scientists in the fields of psychiatry and psychology.

Therefore, an enormous amount of fMRI studies focusing on the amygdala has been published recently. However, there are still efforts which address the issue of artefact reduction in raw images of the amygdala [e.g. 1-5] which aim at more reliable fMRI results in this region. In the present study we tested some suggested simple modifications of a standard gradient-echo (GE) EPI-sequence regarding the quality of corresponding raw images. Applying a commonly used paradigm for emotional face processing, we especially focused on robust activation of the amygdala.

Methods

11 human adults participated in the study which was performed at 3 Tesla (Siemens TRIO). Section-orientation was chosen to follow the standard used in our lab that is an orientation parallel to the AC-PC-line. The following specific parameters were used for the respective four T2*-weighted versions of the GE EPI-sequence (the corresponding abbreviations are composed of a combination of the values for TE and section thickness):

36-4: TE 36ms, phase partial fourier (PPF) 7/8, bandwidth (BW) 1346Hz/pixel, section thickness 4mm.
36-2: TE 36ms, PPF 7/8, BW 1346Hz/pixel, section thickness 2mm.
27-4: TE 27ms, PPF 6/8, BW 1260Hz/pixel, section thickness 4mm.
27-2: TE 27ms, PPF 6/8, BW 1260Hz/pixel, section thickness 2mm.

All other measurement parameters were identical for the different sequence-versions: TR 2000ms, FoV 192x256mm², Matrix 96x128, phase encoding direction: anterior-posterior, 22 sections.

Emotional faces from the Ekman-series [6] were presented using LCD-goggles (Resonance Technology). In a block-design, twelve repetitions of neutral (8s) and fearful faces (8s), each followed by a control condition (gray screen, 12s), were presented. During the 8s intervals of face presentation, each stimulus lasted 300ms followed by a 200ms gap, resulting in 16 face stimuli per presentation interval. With an additional baseline period for equilibrium purposes one experimental run lasted 8min 12s. Data preprocessing and analysis was performed using BrainVoyager QX and included 3D motion correction, liner trend removal, spatial filtering (Gaussian kernel 4mm FWHM), Talairach normalization, and subsequent group analysis using the general linear model approach with a false discovery rate of q(FDR)<0.05.

Results

As expected, the different versions of the GE EPI sequence suffered to different degrees from susceptibility artefacts (**Figure 1**). The severity of artefacts was more effectively reduced by lowering the section thickness from 4mm to 2 mm compared to a reduction of TE from 36ms to 27ms. As expected, the 36-4 variant revealed the most and the 27-2 version the least signal dropouts.

Regarding the functional experiments (**Figure 2**), we found bilateral amygdala activation in response to neutral faces versus control and fearful faces versus control in the 2mm versions only. Using the sequence variant with the short TE (27-2) resulted in a more reliable activation pattern compared to TE 36ms.

Discussion

Comparing four variants of a standard GE EPI-sequence available on a Siemens Trio we found that a reduction of TE in combination with thin image sections significantly improves the results of fMRI of the amygdala using an emotional face paradigm. More specifically, section thickness represented the more critical parameter compared to TE.

Even though reducing TE results in less T2*-weighting and therefore less BOLD specificity, at 3 Tesla a TE of 27ms turned out to be sufficient for the present functional study. Reducing section thickness results in less volume coverage per unit time. However, in our approach thin sections are important for recording raw data with acceptable signal dropouts and a rather unaffected amygdala region. Therefore, to achieve the desired volume coverage one would have to increase TR correspondingly.

In conclusion we showed that rather than applying advanced modifications to the MR-sequence and/or inconvenient placement of the recorded sections a simple reduction of TE and section thickness is sufficient to reliably detect amygdala activation.

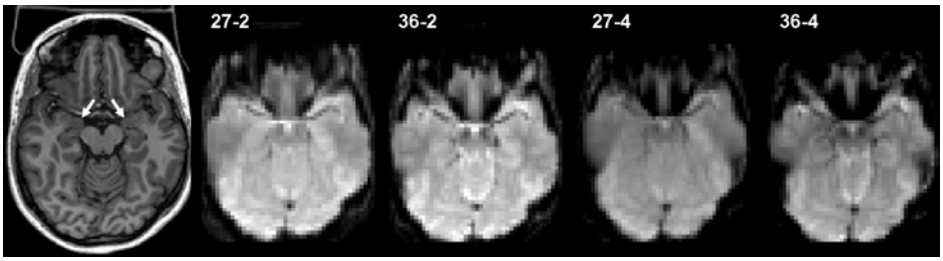

Figure 1: Anatomical MRI of a single subject showing the bilateral amygdala region (left, arrows). Corresponding EPI raw images reveal the different degrees of susceptibility artefacts in respective sequence versions.

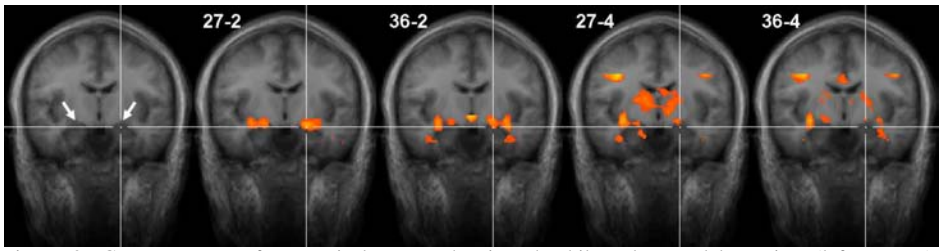

Figure 2: Group-average of anatomical MRIs showing the bilateral amygdala region (left, arrows). Activation maps from the respective fMRI experiments for the comparison of fearful faces versus control.

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