Evaluation of multiband EPI acquisitions for resting state fMRI

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Purpose: Resting state functional MRI (r-fMRI) is a promising technique to illuminate system level alterations in neuropsychiatric disorders. However, current specifications of BOLD-EPI still prevent us from fully examining all spatial and temporal aspects of large-scale brain networks. The recently introduced multibanded EPI technique [1] allows the simultaneous excitation of several slices resulting in considerably shorter single volume acquisition times down to 500 ms. This work evaluates the signal quality of multibanded EPI with several multiband factors and the resulting statistical significance of large-scale r-fMRI networks.

Methods: 4 subjects (age 25±2y) were scanned on a Philips Ingenia 3 T scanner using a 32 channel head coil. We used a multiband EPI sequence (Gyrotools, Zürich) with blipped-controlled aliasing [2, 3] r-fMRI data were acquired for 7 min using four protocols with different multiband factors (m), repetition times (TR) and number of volumes (n): m=1, TR=2sec, n=210; m=2, TR=1sec, n=420; m=3, TR=0.7sec, n=610; m=4, TR=0.52sec, n=810. Common parameters were: SENSE factor 2, matrix 64x64, 36 slices, voxel size 3x3x3 mm^3 and gap 0.3 mm. Additionally, an isotropic T1w anatomical 3D-TFE data set was acquired. Analysis was carried out using Probabilistic Independent Component Analysis [4, 5] as implemented in MELODIC (Multivariate Exploratory Linear Decomposition into Independent Components) for the complete data sets comprising 210 to 810 volumes, and for subsets of 210 volumes for each multiband factor. The set of spatial maps from the group-average analysis was used to generate subject-specific versions of the spatial maps, and associated time series, using dual regression [6].

Results: Table 1 summarizes the whole brain temporal SNR and z-values after the dual regression analysis for the complete data sets. While the SNR decreases , the mean z-value is remarkably stable with increasing multiband factor. We evaluated 4 resting state networks (see Table 1). The statistical maps of these networks generally showed good agreement in their spatial localization for different multiband factors which is shown exemplary for the default mode network (DMN) in Figure 1. Analysis of the subsets of only 210 volumes revealed that it is still possible to distinguish the same networks up to a multiband factor of 3.

Table 1: Subject averages of whole brain temporal SNR (mean ± stddev) and z values (mean ± stddev) for different networks and different multiband factors m.

m	SNR	DMN	Motor	Visual	Fronto-par.
1	61.5 ± 2.6	8.0 ± 8.8	8.7 ± 12.8	8.2 ± 12.9	8.2 ± 9.8
2	58.5 ± 0.7	5.8 ± 5.8	6.1 ± 3.1	5.7 ± 2.3	6.6 ± 4.1
3	46.2 ± 2.7	8.3 ± 13.6	8.7 ± 12.1	7.6 ± 6.1	8.3 ± 10.0
4	28.1 ± 1.2	8.6 ± 10.6	9.4 ± 13.3	8.6 ± 13.7	8.6 ± 10.8

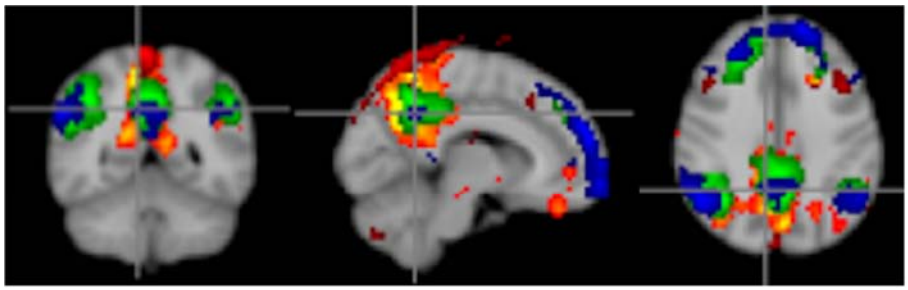

Fig 1: Default mode network for for different multiband factor overlayed on the standard MNI 152 template (m=1: yellow, m= 2: green, m=3: red, m=4: blue).

Discussion: Even though the temporal SNR decreases as could be expected from the heavily undersampled data combining a SENSE factor of 2 with multiband factors up to 4, the mean z-values and spatial representation of the four investigated networks were remarkably stable. The analysis of subsets of only 210 volumes suggests that the use of the multiband EPI technique may even permit to considerably shorten r-fMRI acquisitions e.g. in clinical studies. Else, it is possible to acquire at least the double number of volumes in a r-fMRI acquisition (using multiband factor of 2) in the same time which provides more robust resting state networks in the analysis. The possible reduction in total acquisitions time or the alternatively improved visualization of resting state networks could make multiband EPI the new standard in (r-)fMRI.

References [1] Feinberg et al. J Magn Reson 229:90-100, 2013. [2] Breuer et al. Magn Reson Med. 53(3): 684-91, 2005. [3] Setsompop et al. Magn Reson Med. 67(5):1210-24, 2012. [4] Beckmann et al. IEEE Transactions on Medical Imaging 23(2):137-152, 2004. [5] Beckmann et al.. Neuroimage 25(1):294-311 2005. [6] Beckmann, et al. OHBM, 2009.