Doubling BOLD signal in auditory cortex by acoustic modification of echoplanar sequence

K. Scheffler[1], E. Seifritz[2]

[1]Dept. of Medical Radiology, MR-Physics, University of Basel, Switzerland, [2]Dept. of Psychiatry, University of Basel, Basel, Switzerland

Introduction

Conventional EPI is composed of slice selective excitation followed by a read-out train that consists of a rapidly switched, alternating read gradient and small gradient blips in phase encode direction. The resulting gradient noise generated by repeated EPI acquisitions is thus characterized by a high frequency component of about 500-1000 Hz from the read-out gradient plus a low-frequency component of about 8-12 Hz generated by the repetition of consecutive slices (assuming an acquisition time of 80-120 ms per slice). This type of gradient noise is very similar to pulsed sounds that represent a particularly salient acoustic stimulus for the auditory system (1). In contrast, continuous tones or pulsed tones with a very high repetition rate (>80 Hz) produce a negligible BOLD response (2). Here we present an EPI acquisition method (**L**ow **I**mpact **N**oise **A**cquisition, LINA-EPI) that produces a continuous gradient noise composed of two frequency components of 140 Hz and 600 Hz. This method has identical T2*-weighting and a slightly increased acquisition time of about 10% for the current implementation compared to conventional EPI.

Implementation

For LINA-EPI the continuous read-out and phase encoding train after excitation was divided up into several, separated blocks. Each block consists of 5 read-out pairs (10 echoes) and 10 phase encoding blips. Consecutive blocks are separated by a time period of 2 ms that is required for slice selective excitation at the beginning of the echo train (see Fig. 1). Additional gradients required for slice selection, phase/read dephasing, and spoiling have been implemented with very low gradient amplitudes and long rise and fall times (2 ms). These additional gradients have been added to the continuously running read-out blocks. The resulting noise is dominated by the consecutive read-out gradient blocks that generate mainly two frequencies of 140 Hz and 600 Hz. The slowly switched gradients are imperceptible.

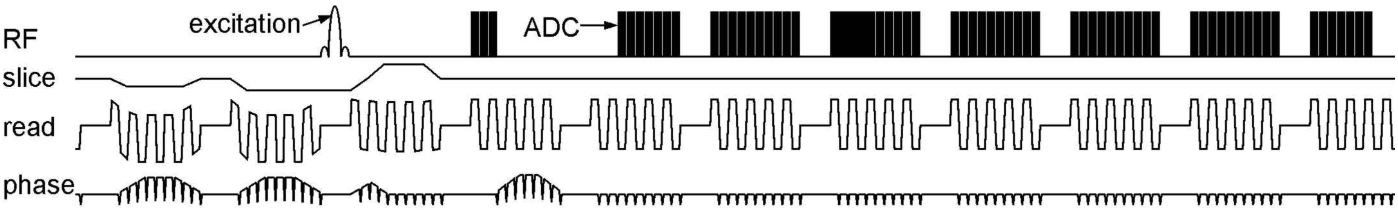

Fig. 1: Fast repetition (140 Hz) of short EPI readouts produces a continuous gradient noise without interruption between consecutive slices

Results

Fig. 2 shows a comparison of image quality between conventional and LINA-EPI. Residual ghosting generated by non-linear increasing echo times of consecutive echoes is only visible in regions with high susceptibility differences. Fig. 3 shows the BOLD time courses acquired with conventional and LINA-EPI during presentation of various sounds. LINA-EPI produces a nearly doubled BOLD response compared to conventional EPI.

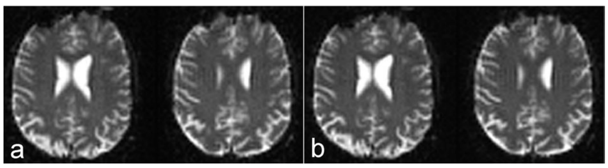

Fig. 2: a) LINA-EPI and b) conventional EPI

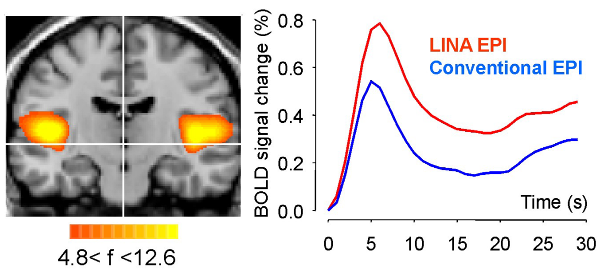

Fig. 3: BOLD response to sounds

Conclusion

Modification of interrupted gradient noise to continuous background noise decreases excitation of the auditory cortex by approximately 50%, and leads to an approximately doubled BOLD response to simple and complex sounds. In addition, continuous LINA-EPI sound is rated more pleasant by the subjects and can increase comfort during scanning. The LINA-principle can be used also with parallel imaging and other non-EPI MRI sequences and will profit likewise from noise attenuation expected from future scanner designs.

References

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(2) Giraud AL et al. *J Neurophysiol* 2000;84:1588-98.