Effect of head motion on the MRI visibility of cortical layers in human primary visual cortex

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Introduction: At $B_0 \geq 3$ T sufficient spatial resolution can be achieved to observe myelinated cortical layers (e.g. the Stria of Gennari) even *in vivo* [1]. When there is head motion, it is difficult to identify such layers reliably, because even small motions can produce ghosting leading to pseudo-layers. If no motion-free reference is available, these small motion artifacts in MR images are hard to detect. We demonstrate using simulations how in-plane motion influences the visibility of cortical layer structures.

Methods: Simulations were programmed in Matlab (TheMathWorks Inc. R2008b). To exclude other artifacts, we simulated the effect of motion on a very high resolution *ex vivo* TSE brain image. (MR system: Siemens MAGNETOM 7T, TR = 4300 ms, TE = 28 ms, FOV = 125×115 mm^2, matrix = 832×768, slice thickness = 0.5 mm, readout bandwidth = 70 Hz/pixel, turbo factor = 3). We calculated translated or rotated versions of the Fourier transform of this image. A new, 'motion-corrupted' Cartesian k-space representation, in which the brain moves between the sampling of two consecutive lines, was constructed from these k-space representations. For instance, the first readout line for the new k-space was copied from the k-space image of the initial position, the next readout line from the k-space image of the image with the updated position etc. The corrupted k-space data were then transformed back into image space.

Results: Simulated abrupt motion near the center of k-space resulted in pseudo-layers. As an example, Fig. 1 shows details of a cortical layer structure in the original (a) and a corrupted (b) image, where a sudden translational motion of 7 pixels (~1 mm) in the readout direction between the two central k-space lines was simulated. Figure 1 clearly shows two dark stripes in the uncorrupted image (a) whereas in the corrupted image (b) three stripes can be identified. From Fig. 1 profiles transverse to the direction of the cortical layer were taken (Fig. 2). The two or, respectively, three layers are represented in the profiles as dips in intensity indicated by the arrows.

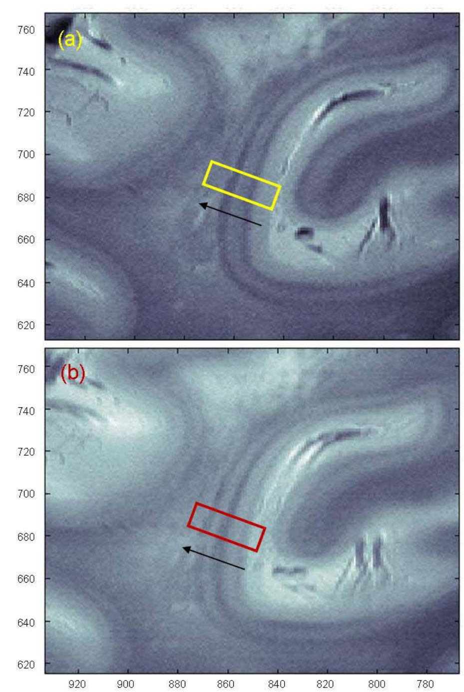

Figure 1: The MR images showing part of the visual cortex V1 without (a) and with motion (b). In the uncorrupted image two darker cortical layers can be clearly differentiated whereas in the corrupted image three dark stripes are visible. Intensity profiles were generated along the boxes (Fig.2).

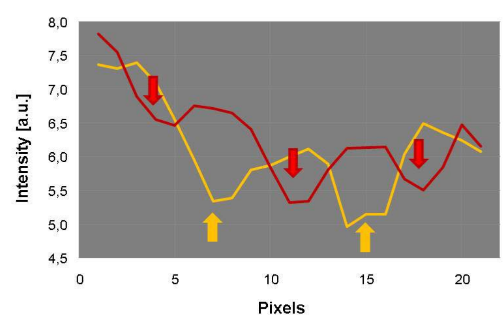

Figure 2: Profiles taken vertically to the cortical layers in the uncorrupted (blue) and the corrupted (red) image. The arrows correspond to the dark stripes seen in the cortical layer.

Conclusion: Simulations show that pseudo-structures can be introduced by motion, which must be taken into account when interpreting high-resolution images. During *in vivo* experiments, no reference image can be used for comparison and artifacts from more complicated motions may be even harder to detect. Such artifacts are best corrected at source, for example by means of external optical motion tracking [2] with prospective motion correction.

References:

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