Residual effects of Large Vessels in GE BOLD Differential Mapping of Ocular Dominance Columns

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Introduction:

The mapping of high resolution functional structures, such as ocular dominance columns relies on the ability and the expectation that the technique being used minimizes the contamination of non-specific large vessel signals. Animal studies have used non-conventional functional imaging methods, such as the ‘initial dip’ (1), cerebral blood flow (2), and contrast agents (3) to address this issue. Signal to noise limitations, even at high magnetic fields; make it difficult to apply these techniques in humans. Previous human studies (4-6) instead used the conventional GE BOLD technique, combined with differential mapping. We have previously demonstrated the ability of HSE BOLD imaging and differential mapping to reliably and robustly map ocular dominance columns in humans. Here we investigate the potential and limitations of GE BOLD differential mapping as compared to HSE BOLD differential mapping of ocular dominance columns in hopes of developing a strategy for high resolution applications in humans at high magnetic fields.

Background:

The spatial specificity and sensitivity of both HSE and GE BOLD increases with magnetic field strength. At high magnetic fields, the HSE BOLD fMRI technique starts to become plausible, in terms of sensitivity and CNR, and for many functional imaging applications an alternative to the high sensitivity GE BOLD signals. In addition, the HSE BOLD technique has the added advantage of intrinsically minimizing the contributions of extravascular BOLD signals around large vessels due to the refocusing pulse. On the other hand, GE BOLD signals, while maintaining the highly spatially specific components, have to deal with the contamination of large vessel signals which are present and can spread some distance away from the vessel, potentially blurring signals from smaller vessels. Differential mapping techniques, which impose apriori knowledge about orthogonal conditions, are often used in imaging to subtract out global non-specific signals in order to exploit the signals originating from the microvasculature.

Methods:

Studies were conducted at 7T using a 12 segment EPI acquisition (TR/TE 6000/25 ms) for GE studies, which we considered an optimal approach based on previous studies (4,5), as opposed to the slab selective FOV reduction for HSE (TR/TE 6000/50 ms) with 3 image segments, which we found to be optimal for HSE studies. The spatial resolution was: 0.5 x 0.5 x 3 mm^3 for both sequences with minimal resolution loss due to EPI blurring along the phase encode direction. To minimize the effects of motion; subjects used a bite bar, image registration of small motion was used within and between scans, and scans with large amounts of motion and / or significant mis-registration problems, were discarded. The visual stimuli were presented through fiber optic video goggles (Avotec, inc.). Subjects were brought back for repeated studies to assess the reproducibility of the functional maps. The maps from different sessions were co-registered to allow for identification of similar columns in the different sessions.

Results:

The results from one subject, both GE and HSE data from three different sessions (over the period of several months), are shown in Fig.1. The displayed maps are differential maps (i.e. right eye minus left eye, with a confidence of 85%. The right and left eye columns are indicated by blue and yellow arrows, respectively. The location of the arrows does not change from one image to the next. Columnar patterns appear and are similar between the two contrasts in the lower portion of the FOV shown, while in the upper portion, the GE map no longer resolves these patterns. Irrespective of the spatial characteristics of the functional map (i.e. whether there are columns or not) the maps are highly reproducible. If differential GE BOLD is to be used to resolve structures at the sub-millimeter level, additional approaches (e.g. 4, 5) to minimizing large vessel contributions should be employed. Our findings suggest that HSE BOLD fMRI would be the more optimal approach in the *general* case of employing differential mapping techniques at high resolution.

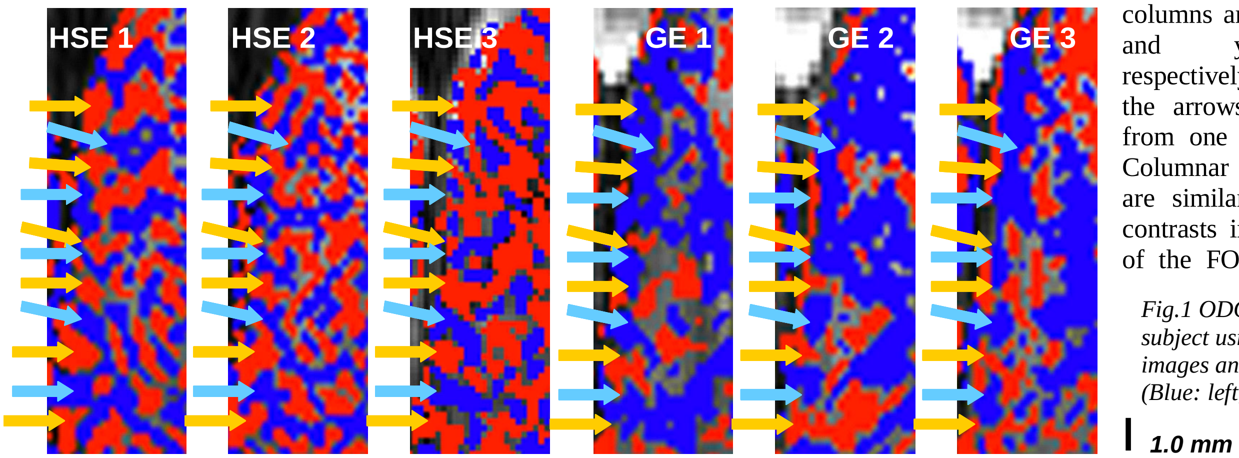

Fig.1 ODC maps from the same subject using GE and HSE BOLD images and differential mapping. (Blue: left, Red: right)

References: **1**. *Kim et al 2000* **2**. *Duong et al 2001* **3**. *Harel et al 2002* **4**. *Menon et al 1997* **5**. *Cheng et al 2001* **6**. *Dechent et al 2000.*

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