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Mercredi 15 juin 2005
Conférence Analyse d'Images

15h00 – 15h45

Hemodynamic responses in cortex studied by high-resolution optical imaging: Implications for functional brain mapping

Spatio-temporal Characteristics of Sensory-evoked Changes in Cerebral Blood-Volume and -Oxygenation

One of the ultimate goals of functional brain mapping is to image the activity pattern elicited by a given sensory stimulus, at the spatial resolution of the "fundamental information processing modules", the cortical columns. For this purpose, single-condition imaging (difference between a stimulus and the non-stimulated condition) is preferable over differential imaging (difference between the activity patterns elicited by two stimuli). Indeed, truly orthogonal stimuli (i.e., eliciting non-overlapping activity patterns) are rarely available, in particular when studying higher cognitive functions.

The spatial scale at which any given hemodynamic signal used for functional imaging is regulated by local electrical activity sets the upper limit for the spatial resolution achievable - independently of the technique used. It is thus important to identify the components of the hemodynamic response which co-localize with electric activity at the columnar level, and to separate them from those which do not. Yet, the spatial precision of the neurovascular coupling remains controversial.

We will report the results of blood-volume and –oxygenation measurements in the anesthetized cat. Changes in oxygenation were found to precede the onset of blood-volume increase. Furthermore, the high spatio-temporal resolution of optical imaging warranted to isolate the responses of the different microvascular compartments. The results will be discussed with respect to the Balloon Model (Buxton et al.).

We will also report on imaging experiments performed on the awake behaving macaque. The raw data support the concept of a better localization of an initial increase in deoxyhemoglobin (associated to oxygen consumption) as compared to the subsequent volume and flow increase.

Finally, functional maps obtained upon imaging different hemodynamic signals were similar but not identical, raising the question of whether the same or different regulatory mechanisms underlie the various hemodynamic processes.

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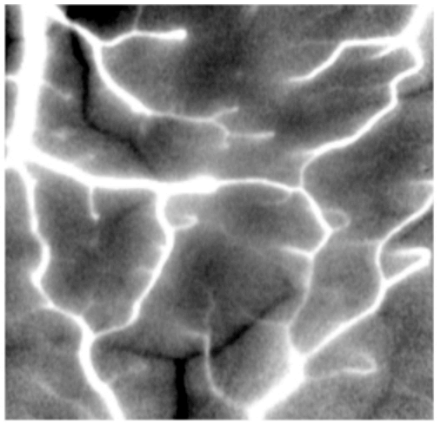
Hypo-oxygenation



Hyper-oxygenation

Difference in spatial resolution characteristic to different hemodynamic processes.

Both images (~3x3 mm) were obtained using optical imaging of intrinsic signals in the primary visual cortex of an awake monkey, viewing monocular stimuli (drifting oriented gratings) intermingled with a control stimulus, consisting simply in a dark screen. The cortex was illuminated at a wavelength sensitive mainly to changes in the concentration of deoxy-hemoglobin, and both images were obtained by subtracting the control condition from an ipsilateral stimulus. The left image was obtained during the first 3 sec. of the response (corresponding to a transient hypo-oxygenation phase) and shows clearly the well known functional pattern of ocular dominance columns, at high spatial resolution. The right image was obtained during the later time of the response (> 5 s), corresponding to the hyperoxygenation phase underlying the positive BOLD fMRI signal. Here, large vascular patterns dominate the image, making the fine details of the functional patterns unrecognizable.