Imaging Dysfunctional Hyperemia in Ischemic Stroke Patients

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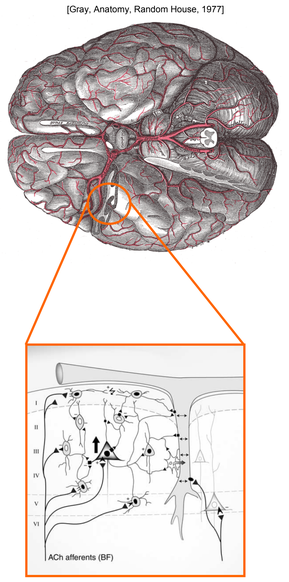
Background

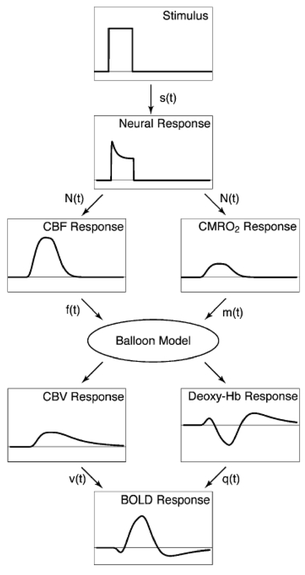
Interneurons and glia help regulate rCBF

[Gray, Anatomy, Random House, 1977]



[Kocharyan et al., J. Cereb. Blood Flow Metabl, 28, 2008]

Functional hyperemia is part of an interplay of neural, vascular, and metabolic factors

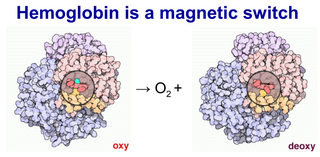


[Buxton et al., NeuroImage, 23, 2004]

- Functional hyperemia causes an increase in regional cerebral blood flow (rCBF) in relation to neural activity
- This process is altered in neurological disease
- Imaging functional hyperemia may contribute to early identification of vascular disease

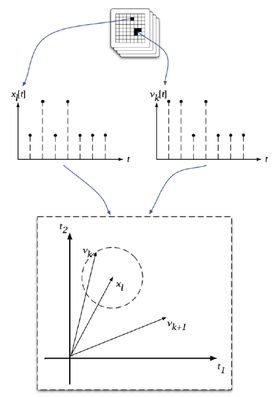
Theory

Hemoglobin is a magnetic switch

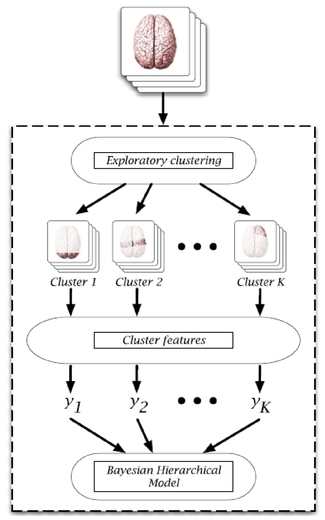


dia-magnetic → para-magnetic

Illustration of correlation-based clustering



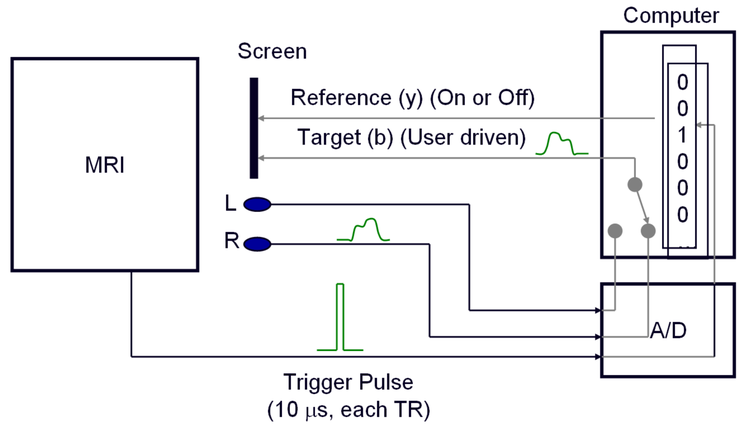
An exploratory pattern recognition model to identify correlated and contiguous voxels



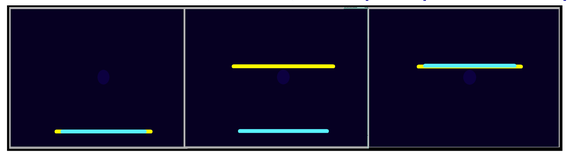
- Blood oxygen level-dependent (BOLD) MRI measures in part rCBF and is used to observe the hemodynamic response to event-related stimuli
- Exploratory pattern recognition algorithms are used to find responding voxels in the BOLD image series
- Voxels having correlated time signals are clustered, and the contiguous clusters in physiologically relevant areas are analysed

Methods

MRI experiment: an event-related visual feedback controlled hand-motor task



Screenshots of the rest, stimulus, and response phases of the experiment

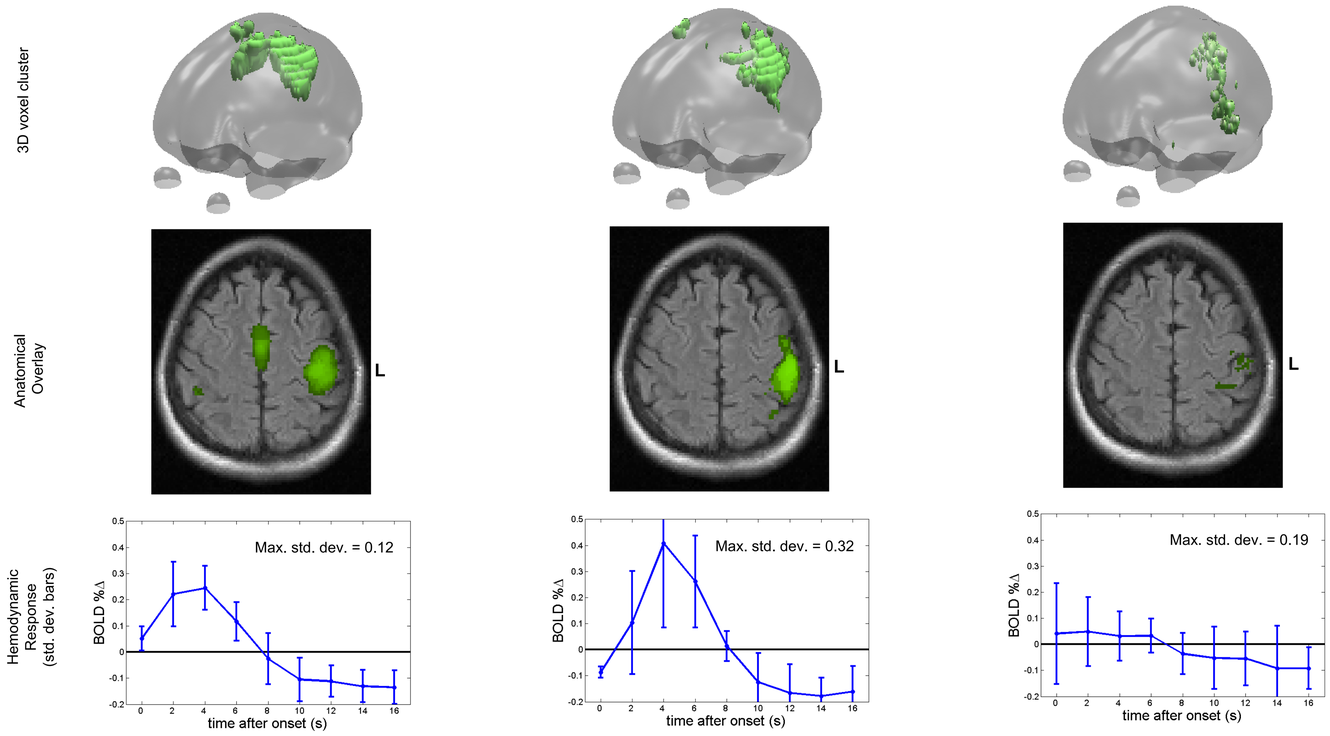


Patient is resting | An event occurs | Patient responds

- Enrolled 3 normal subjects and 4 ischemic stroke patients (9 normal scans, 11 stroke scans)
- Acquired 1.5 Tesla BOLD image series during event-related task
- Visual stimuli were synchronised and physical responses were recorded

Results

Normal subjects (n=9) | **Non-paretic hand of Stroke patients (n=4)** | **Paretic hand of Stroke patients (n=7)**

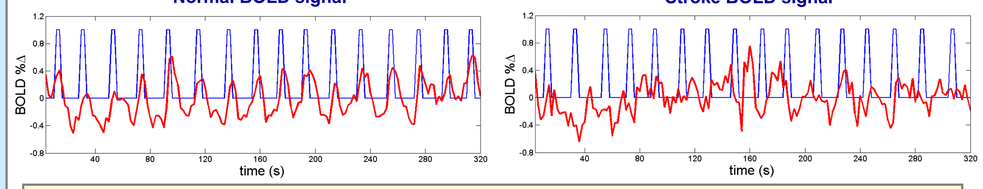


- Aggregate results are shown for normals, and stroke patients' non-paretic and paretic hands
- Images of responding voxel-maps and BOLD event-response signals are shown

- A weaker response is seen in the paretic side, i.e. fewer responding voxels in the motor area
- The standard deviation of responses also rises, indicating inconsistent response signals

Conclusion

Normal BOLD signal | **Stroke BOLD signal**



- Stroke responses do not follow linear correlative models
- The results demonstrate the potential of the method to monitor the state of functional hyperemia during stroke recovery trials

Brief References:

1. C.S. Thompson, and A.M. Hakim, "Living beyond our physiological means—small vessel disease of the brain is an expression of a systemic failure in arteriolar function: a unifying hypothesis," *Stroke*, vol. 40, pp. e322-e330, 2009.

2. H. Girouard, and C. Iadecola, "Neurovascular coupling in the normal brain and in hypertension, stroke, and Alzheimer disease," *J. Appl. Physiol.*, vol. 100, pp. 328-335, 2006.

3. C. Gómez-Laberge *et al.*, "Selection criteria for the analysis of data-driven clusters in cerebral fMRI," *IEEE T. Biomed. Eng.*, vol. 55, pp. 2372-2380, 2008.

Acknowledgements:

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