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TEMPORAL AND SPATIAL CHARACTERIZATION OF PHYSIOLOGICAL NOISE IN RS-FMRI AT HIGH TEMPORAL RESOLUTION

(TR = 125MS)

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Cerebral fMRI is a useful imaging tool that allows to visualize neuronal activity based on blood oxygen levels. However, except the neuronal component of interest, fMRI signal contains "noise" components due to physiological processes (heartbeat, respiration...).

Literature contains attempts to estimate this part of the signal, but not to measure it.

This study aims to measure the respective impact of cardiac pulse and respiratory cycle on MRI signal in human brain and its regions with short TR.

17 MRI exams; 9 subjects (1 to 3 sessions per subject)

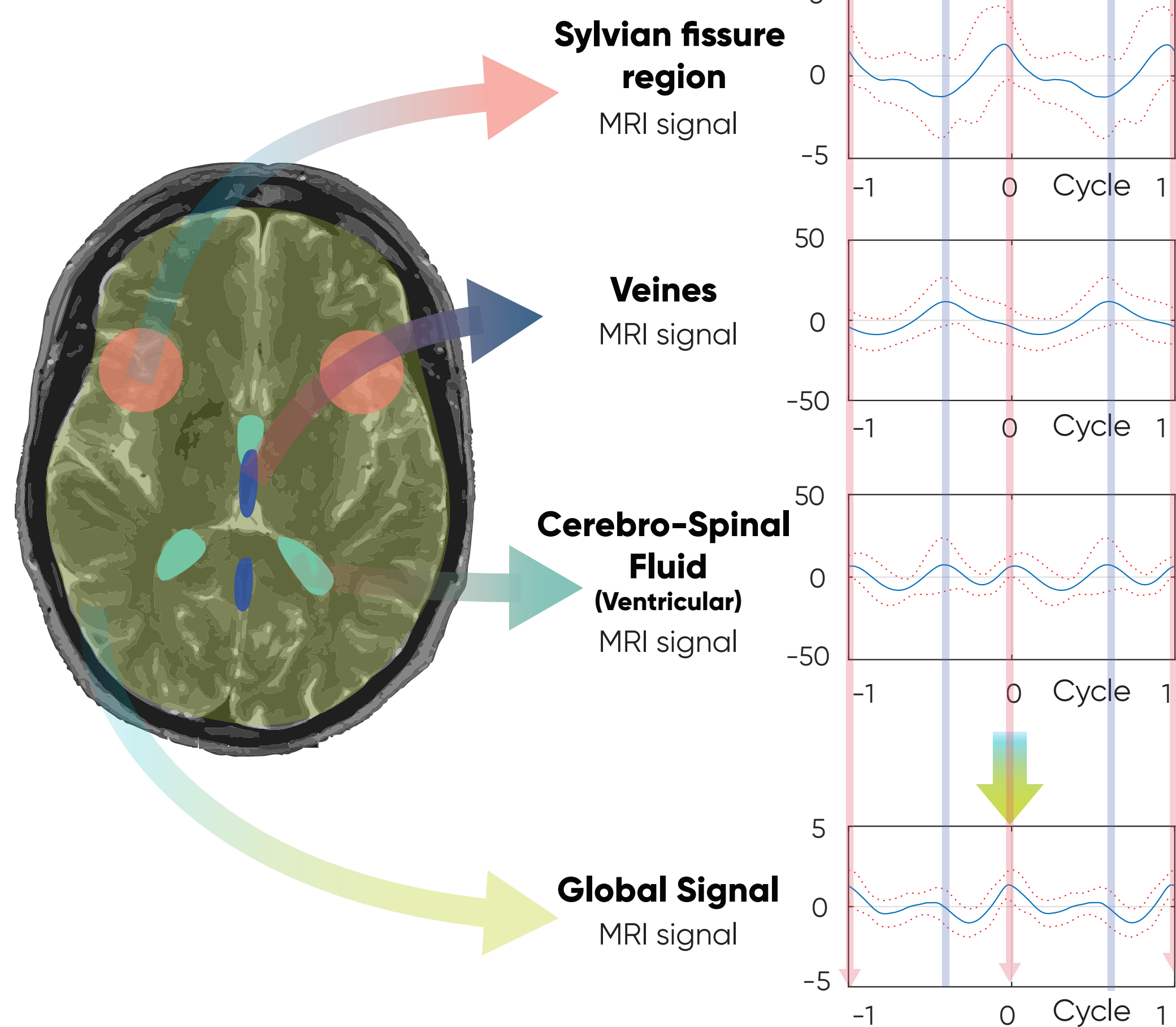
3T Philips MRI scanner
 2D single slice EPI-GE, TR = 125 ms, TE = 30 ms, flip angle = 22°, 5 min 12 sec per session

PPG

Pneumatic thoracic respiration transducer

In time domain: we have computed the grand mean of the average MRI signal of each ROI across each physiological cycle aligned by the peak of each cardiac or respiratory cycle.

— Grand mean
 ... ± STD



The Grand Mean of an MRI signal time series in one of the 4 regions of interest over all cardiac cycles through all scans (15) and all subjects (9).

Each cardiac contraction sends the oxygenated blood to the brain arteries and increases the venous return.

BOLD effect
 The BOLD signal intensity depends on the proportion of Oxygenated vs Deoxygenated blood.

Increase in volume and inflow of Oxygenated blood in the Sylvian arterial regions during Systolic period.

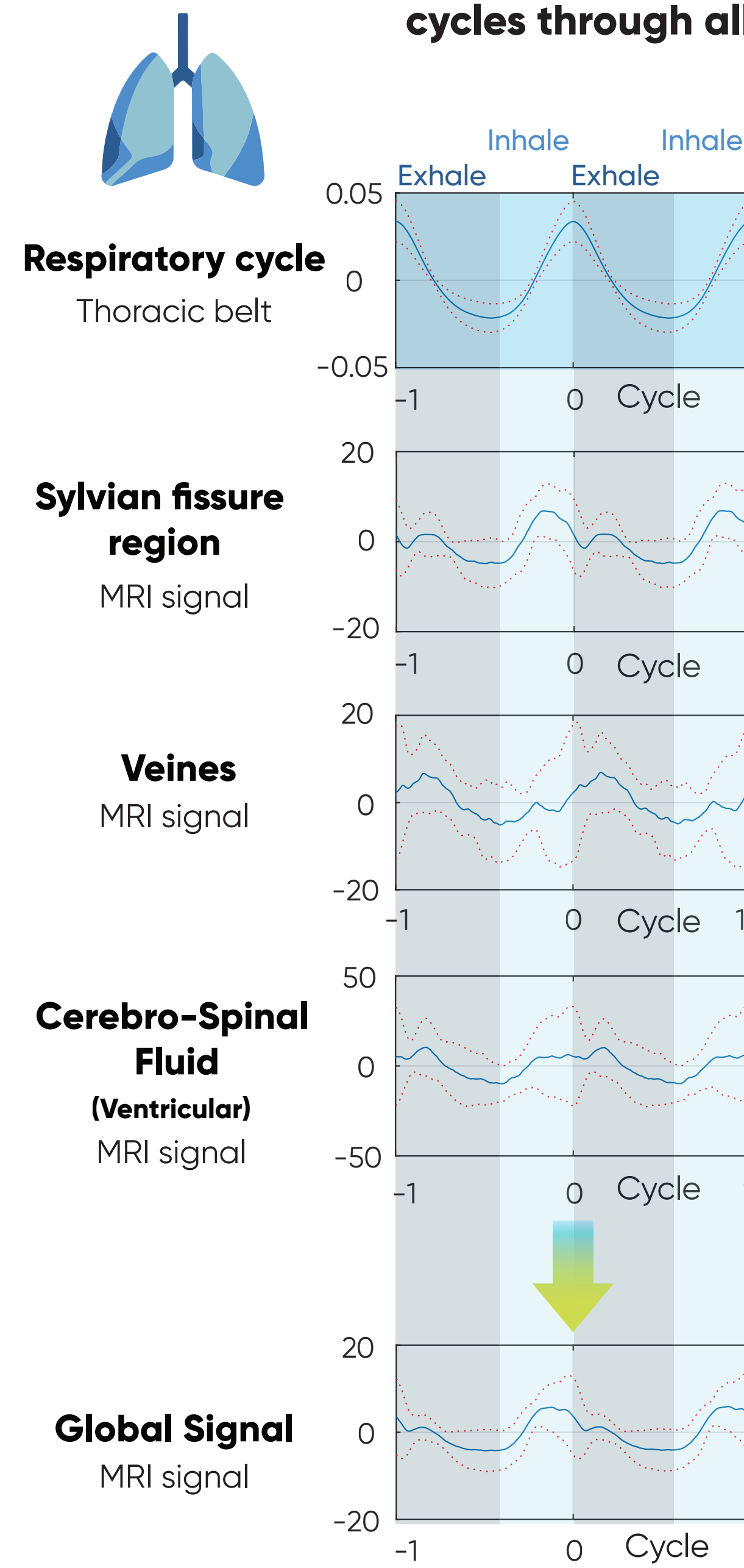
The venous return region signal is inverse in phase with respect to the arterial region signal.

Inflow effect
 The flow of blood/CSF across the voxel of interest during the TR imports "fresh" non-aligned protons which affects the EPI signal.

CSF does not provide the BOLD signal. However, the inflow/outflow effect can provide us with information of the flow of the CSF.

Global Signal represents a sum of the signals from all regions

The Grand Mean of an MRI signal time series in one of the 4 regions of interest over all respiratory cycles through all scans (17) and all subjects (9).



The inhale is accompanied by the drop of pressure in the chest, which increases venous return due to the pressure gradient. The emptying of veins leads to a decreased brain volume, and the compensatory CSF inflow in the meninges.

Inhale increases the proportion of the O₂ blood in the brain and increases the meningeal CSF proportion in the ROI. Both are leading to the increase of the signal.

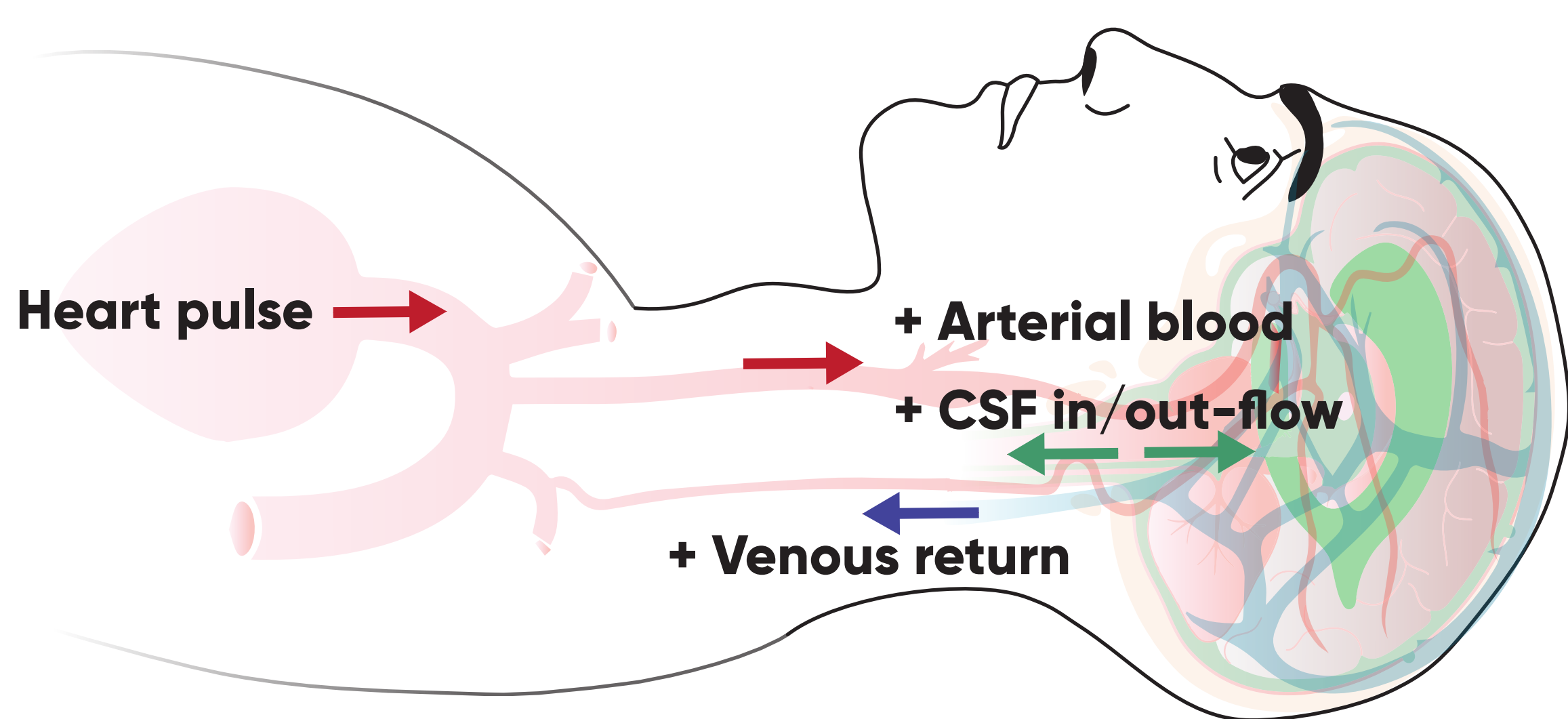
The number of protons in a voxel depends on its tissue composition. For example, the CSF has more protons than bone tissue, which makes its signal "brighter".

During inhale the diaphragm creates low pressure in the chest, facilitating the venous return. The signal increases due to an inflow-outflow effect of the blood flow in veins.

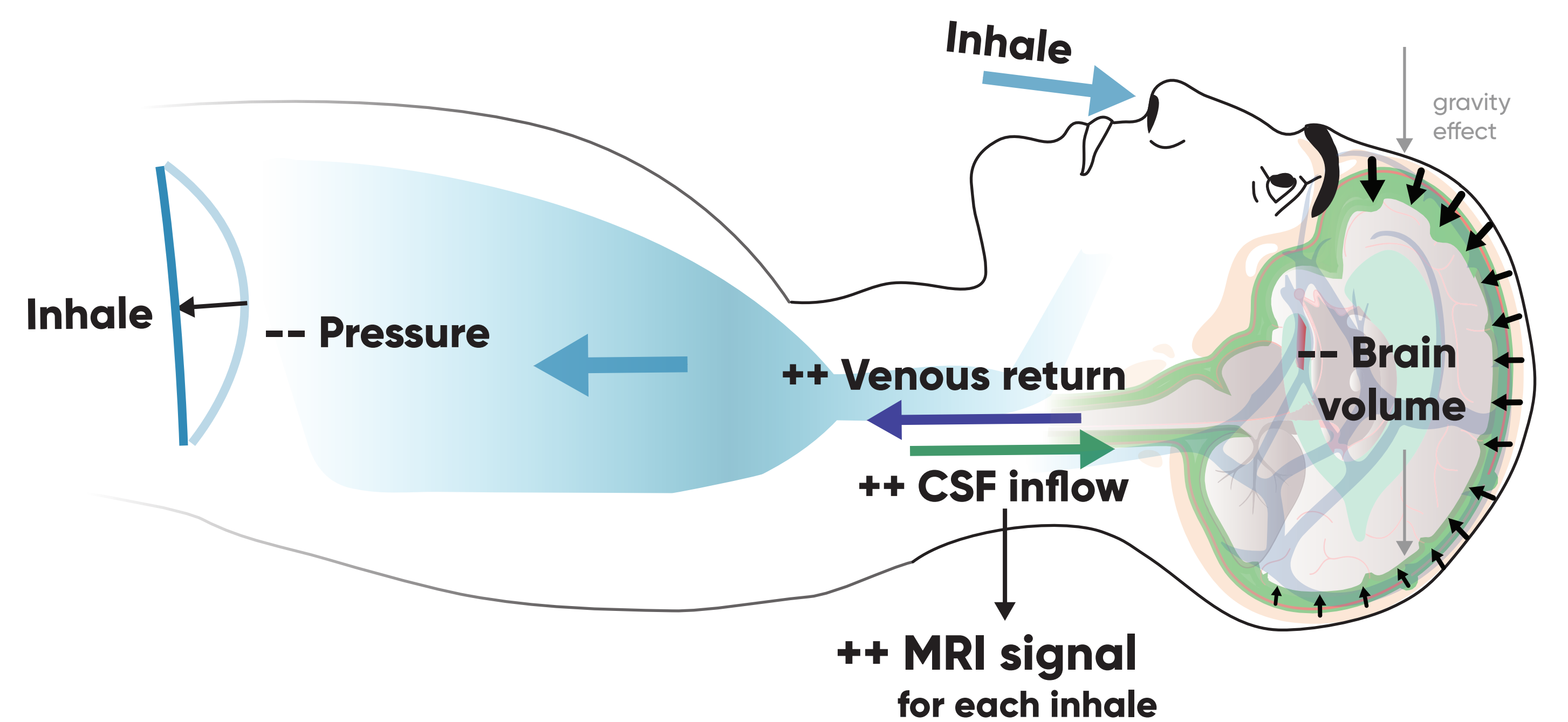
The signal from the CSF in the ventricles reflects the inflow-outflow effect by the respiratory cycle.

The effect of the respiration on Global Signal is more ample than the cardiac pulse effect.

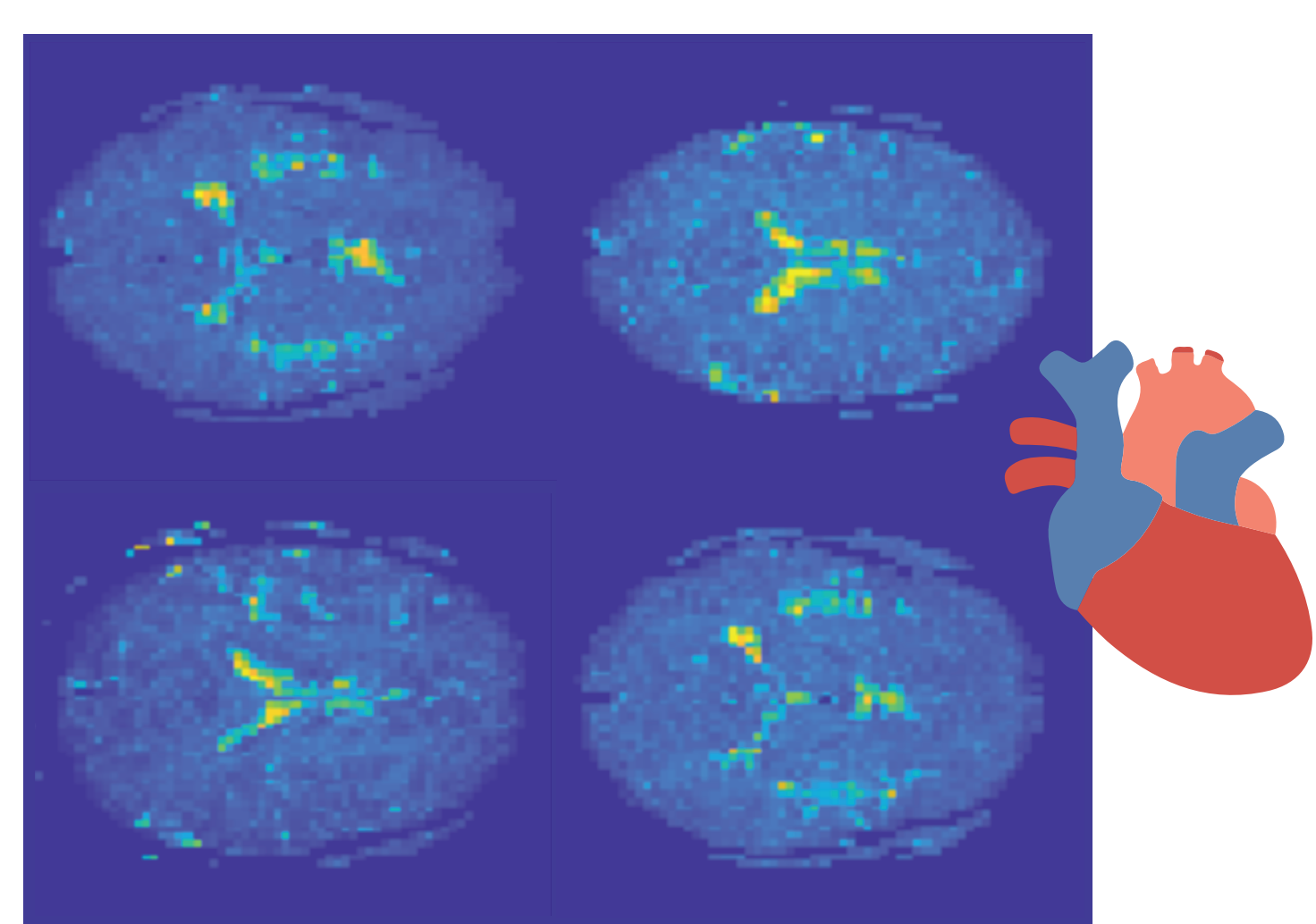
High pressure CSF circulation: the ventricles



Low pressure CSF circulation: the meninges

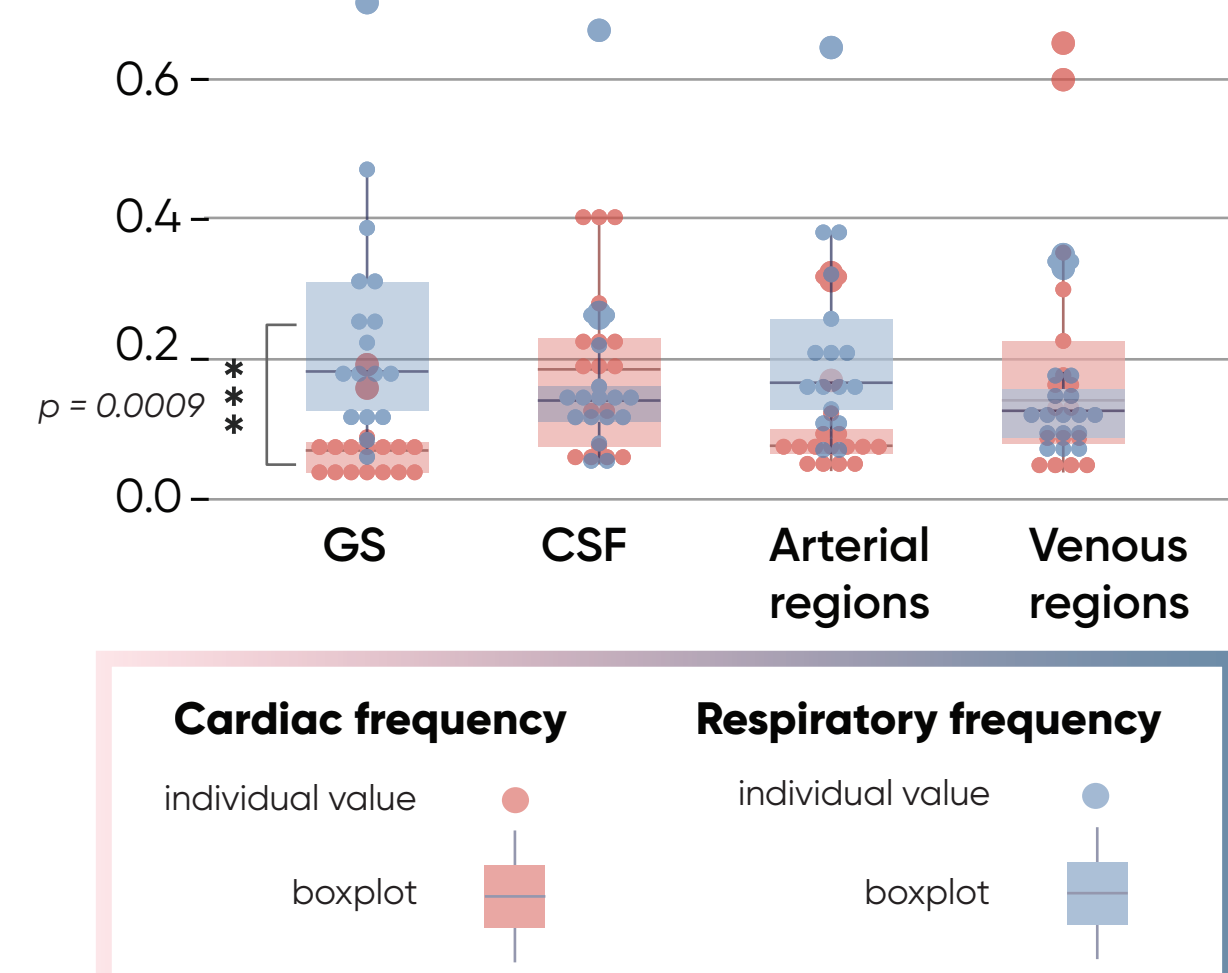


In frequency domain: we have computed the amplitudes of the spectral peaks of the MRI signal voxel-wise, at the respiratory and cardiac frequencies measured for each subject. The amplitudes of these peaks were plotted to depict the regions that are most sensible to cardiac or to respiratory oscillations.



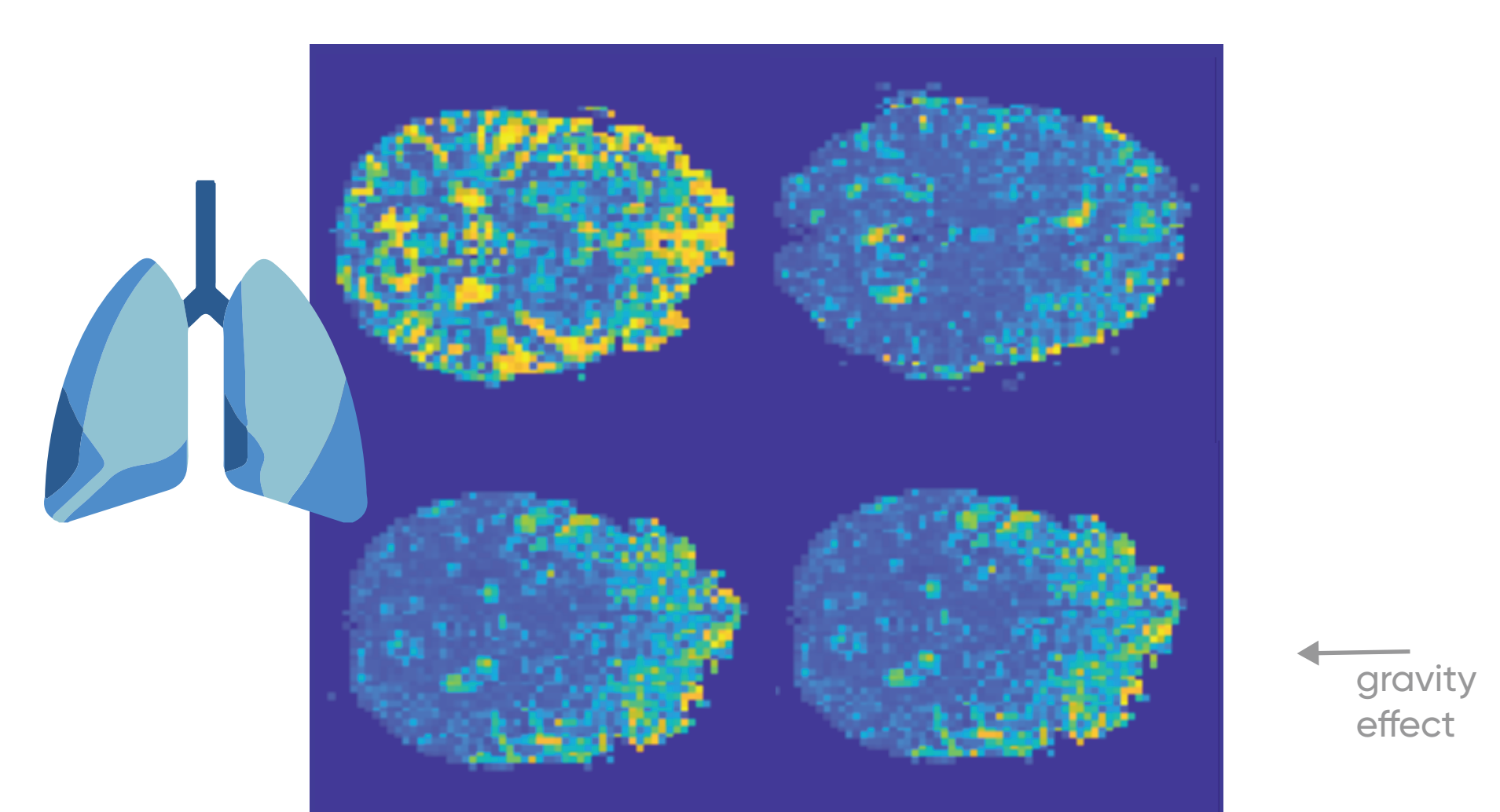
The cardiac effect is most pronounced in the motion of the CSF in ventricles and in venous outflow.

Amplitude of spectral peaks of the MRI signal or each ROI



LMM with (1) ROI and (2) cardiac/respiratory peak spectral amplitude as fixed factors, their interactions, and a subject as a random effect, Bonferroni correction

The respiratory impact in the Global signal is significantly more important than the cardiac impact.



The respiratory effect is most pronounced in the motion of the CSF in the contours of the brain, mostly the frontal part, as in the supine position gravity acts on the floating in the CSF brain, tearing it down to the back of the head.