Whatever I understand doesn't hurt me

Virtual Dinner on laminar fMRI, 07 May 2020

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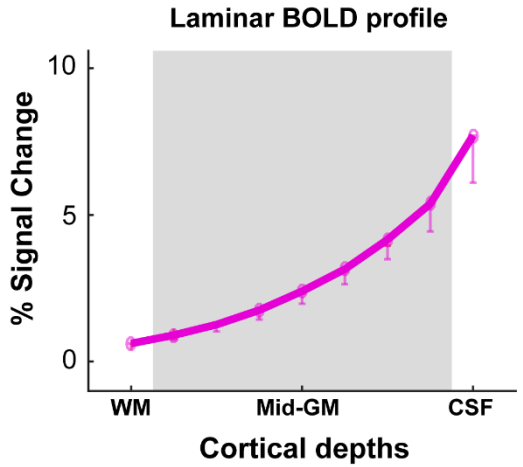
Steady-state laminar GE-fMRI signal

- **Typically BOLD signal (GRE-EPI) increases towards surface:**



Kashyap et al. (2017), NI

See also review by Uludag & Binder (2018), NI

Steady-state laminar fMRI signal

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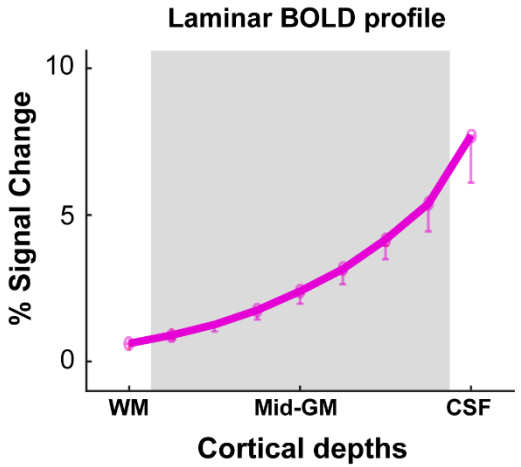

Kashyap et al. (2017), NI

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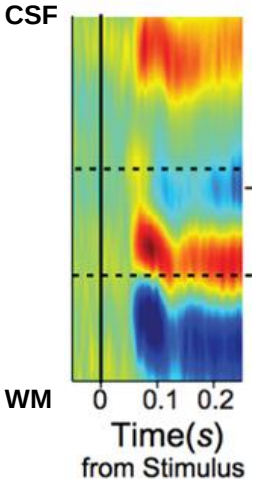
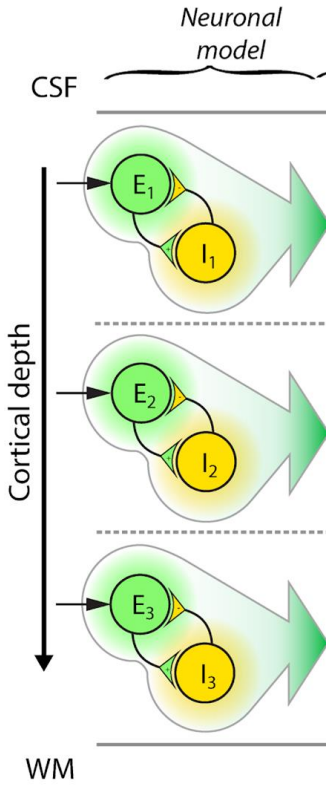
- **Incongruent with electrophysiological profiles**

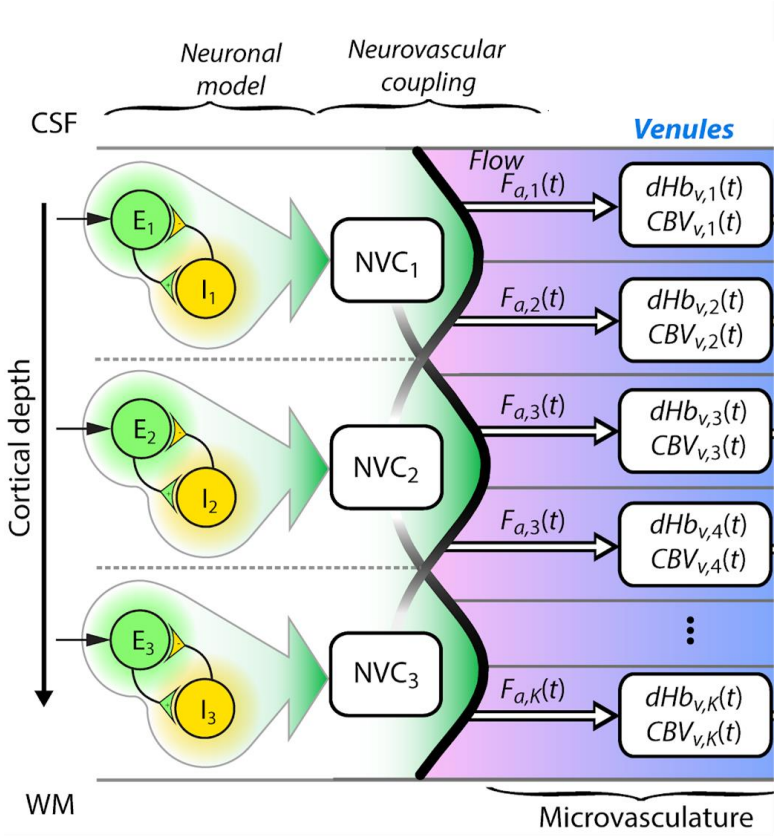


Cox, Dougherty, et al., Cereb Cortex (2018)

From neuronal activity to laminar BOLD signal



From neuronal activity to laminar BOLD signal



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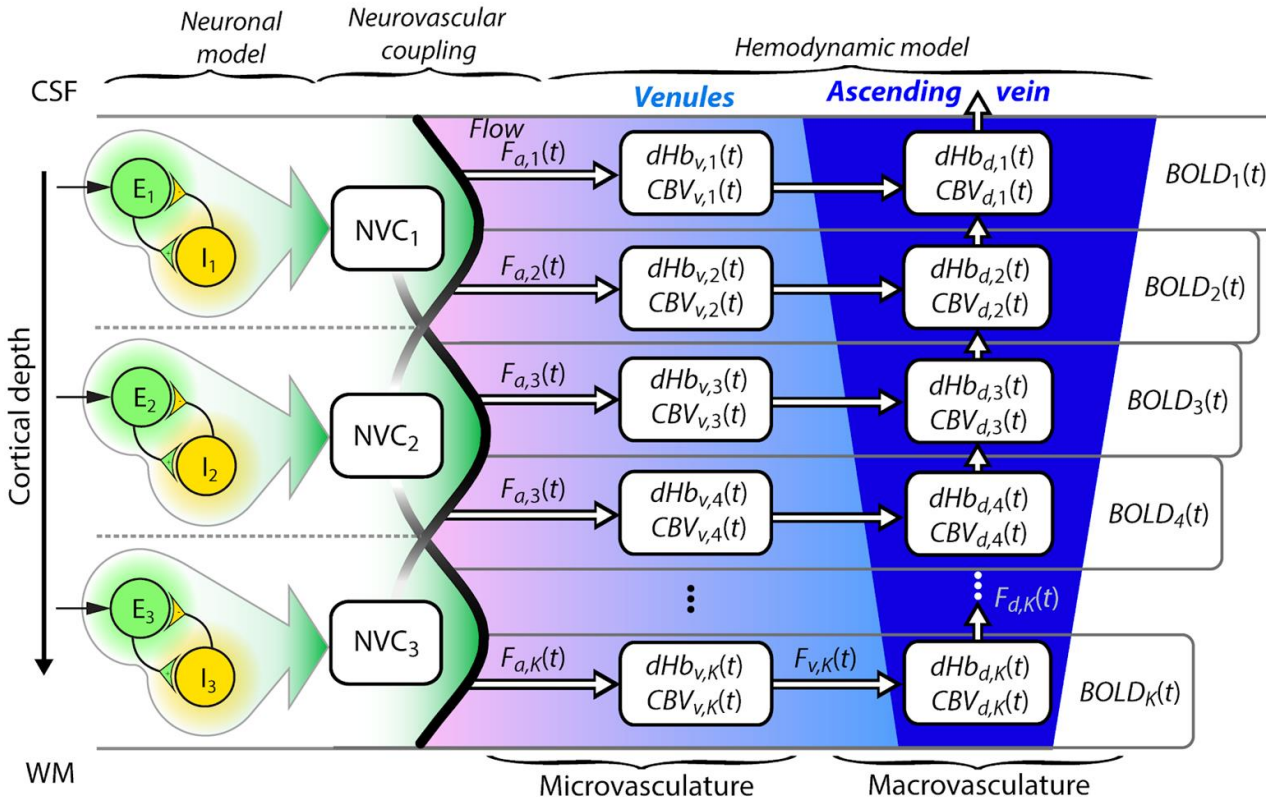
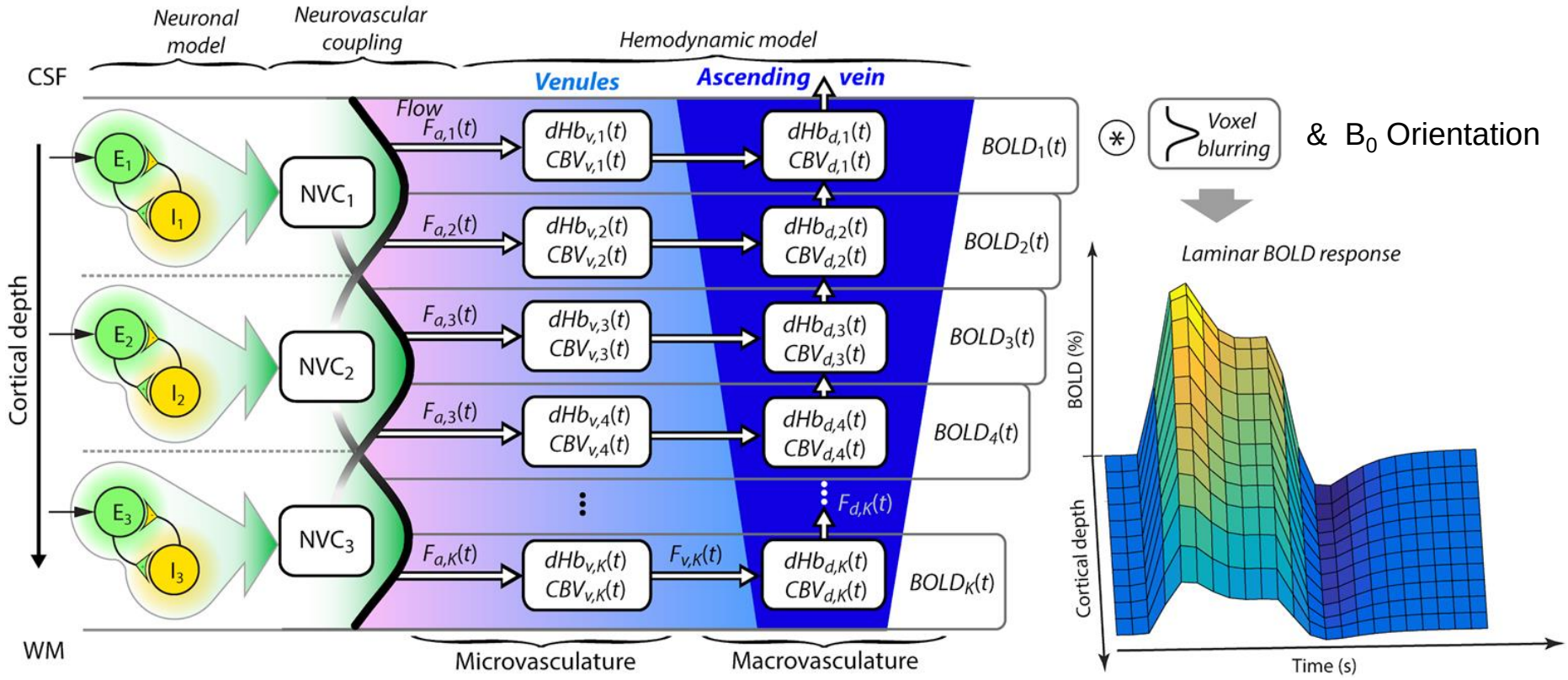


Uni-directional spatial blurring
(Havlicek & Uludag, 2020)

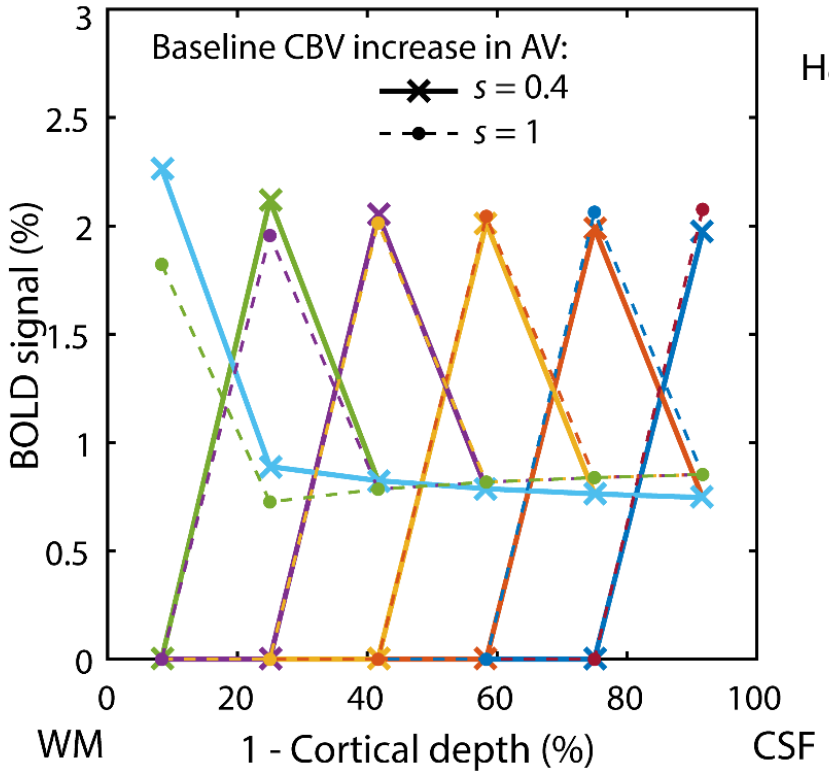
From neuronal activity to laminar BOLD signal



Laminar GE-BOLD signal: spatial and temporal indirect reflection of neuronal activity

→ **Framework allows to optimize and characterize acquisition and analysis choices (e.g. voxel resolution, number of layers, …)**

Leakage between layers



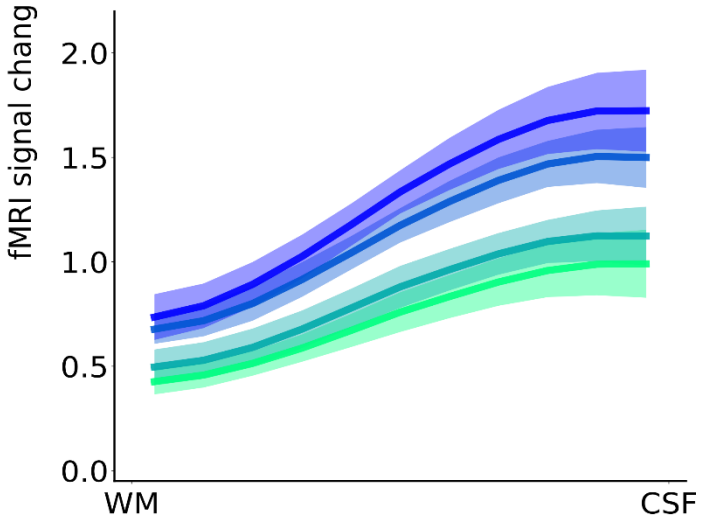
Havlicek & Uludag, 2020

See also Markuerkiega et al, 2015
Heinzle et al, 2016

Activation in one layer is carried over to the upper layers
→ Spatial deconvolution removing ascending vein effect (see Marquardt et al., 2018)

Steady-state spatial “deconvolution”

Before deconvolution



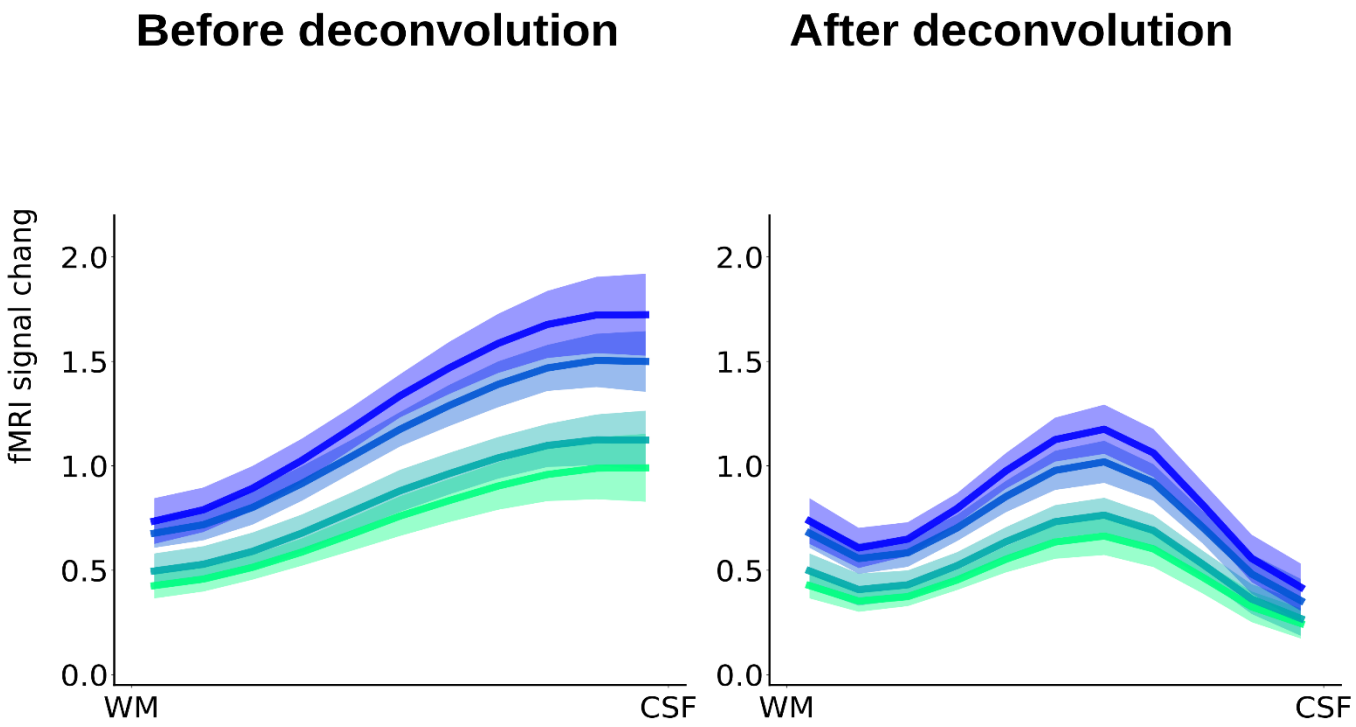
$$LA_6 = S_6$$

$$LA_5 = S_5 - w_{6\to5} \times LA_6$$

$$LA_4 = S_4 - w_{6\to5} \times LA_6 - w_{5\to4} \times LA_5$$

Activation in one layer is carried over to the upper layers
→ Spatial “deconvolution” removing ascending vein effect (see Marquardt et al., 2018)

Steady-state spatial “deconvolution”



Activation in one layer is carried over to the upper layers
→ Spatial “deconvolution” removing ascending vein effect (see Marquardt et al., 2018)

Summary

In GE-BOLD signal, laminar fMRI signal is ascending vein-weighted

→ Unidirectional spatial blurring towards the surface of the cortex

→ Laminar GE-BOLD signal differences may be misleading

Laminar GE-BOLD signal model – based on mass balance principles – can account for this effect during steady-state and transients

→ If correctly accounted, advantages of GE-BOLD approach can be fully exploited (e.g. large brain coverage, high SNR)

→ However, model has to be validated with electrophysiology or other measures (e.g. VASO [see blog Renzo, layerfmri.com], CBF [Kashyap et al, in prep])