Orientation Decoding at multiple resolutions at 7T

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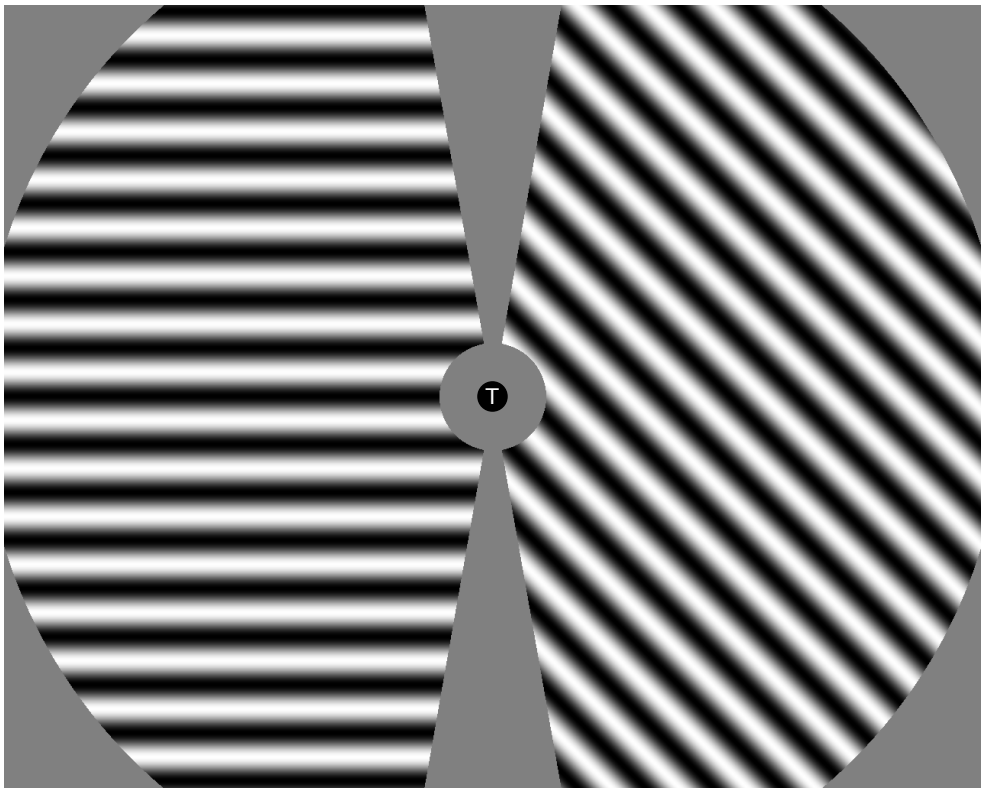
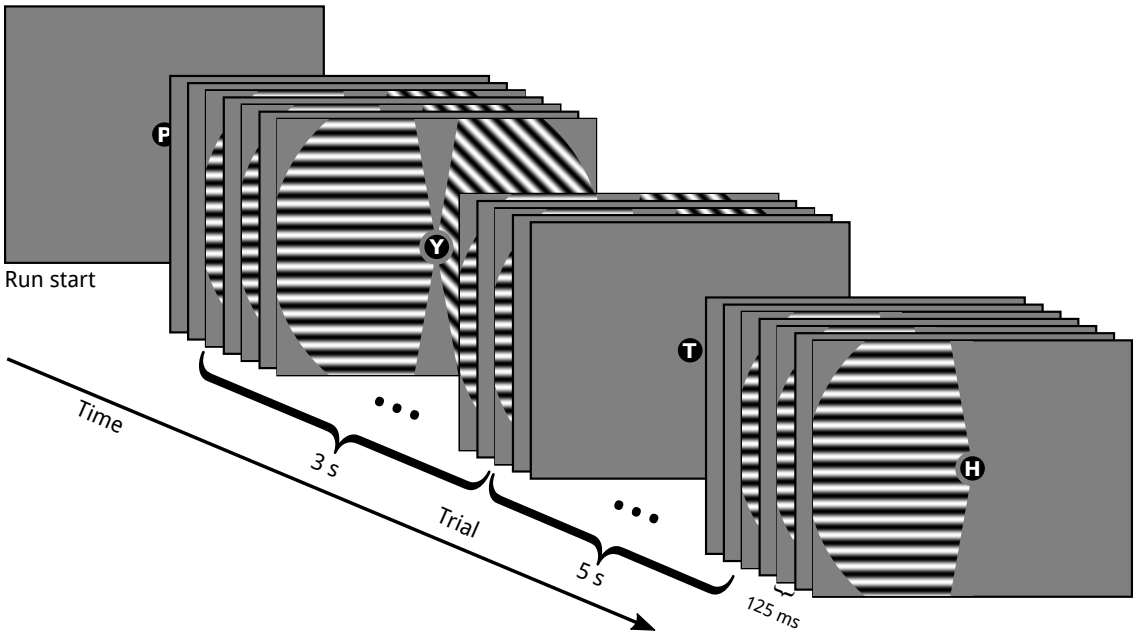
Orientation Decoding in primary visual cortex (V1)



- Most extensively studied paradigm.
- Important studies like Kamitani and Tong (2005), Haynes and Rees (2005), Swisher et al., (2010), Alink et al., (2013) etc.

Stimulus

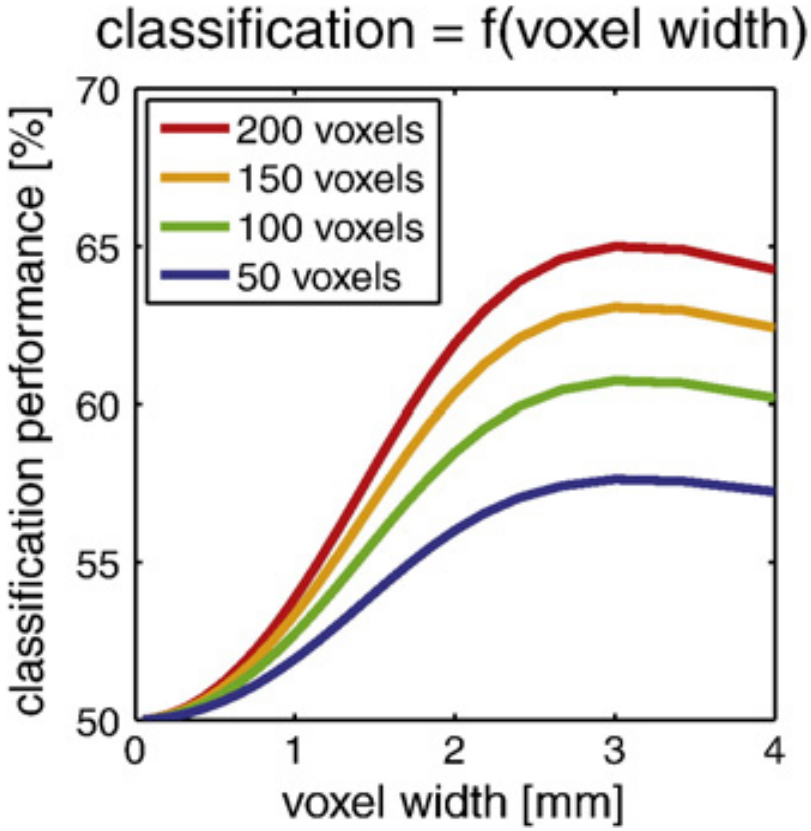


- 30 Trials = 1 Experimental run
- Number of runs = 10
- Total scan time = 40min
- 4 orientations in each hemifield (0°, 45°, 90°& 135°) with random phase shifts

General Workflow of Orientation decoding analysis

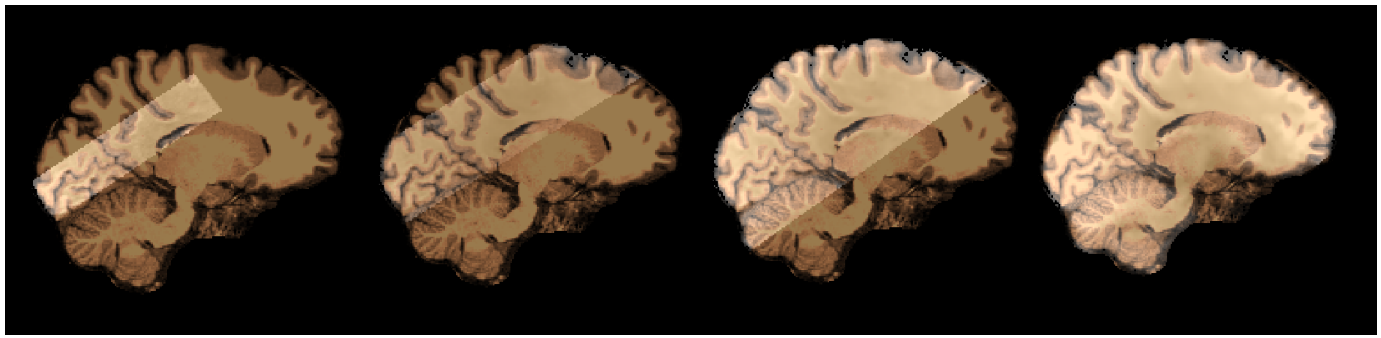
- EPI acquisition in one particular resolution
- Volumetric Gaussian filtering with increase in kernel width (expressed in FWHM)
- Within-subject leave-one-run-out cross-validation with LinearSVM classifier
- Conclusion about the spatial scale of the Orientation specific signals

Simulation Study by Chaimow et al., 2010



- Chaimow et al., 2010 simulated fMRI data to model decoding of ODCs at different acquisition resolutions.

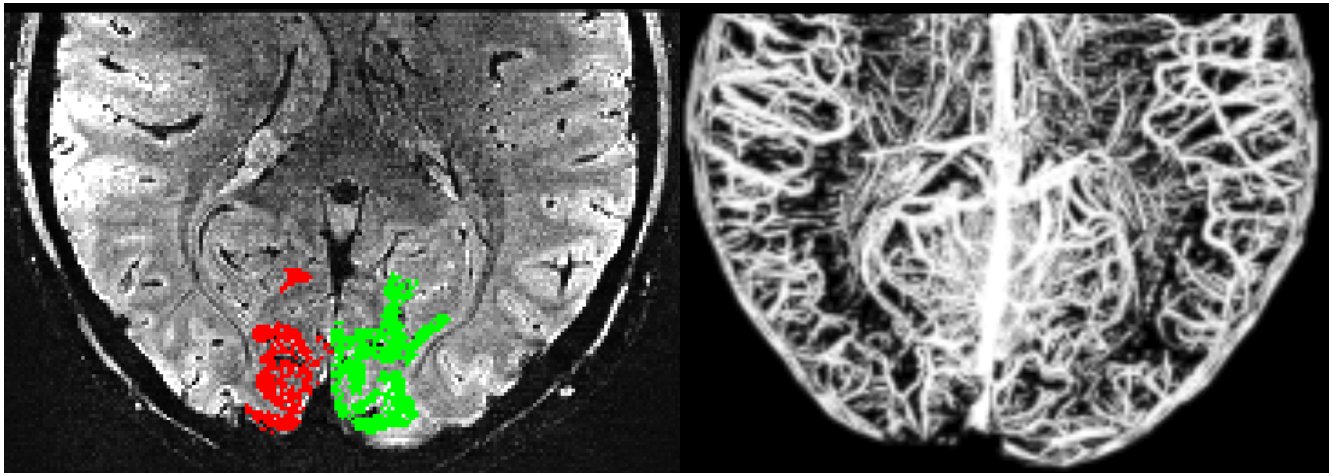
Empirical Study *(under review)*



0.8mm iso Grappa Accel. Factor 4	1.4mm iso Grappa Accel. Factor 3	2.0mm iso Grappa Accel. Factor 3	3.0mm iso Grappa Accel. Factor 2

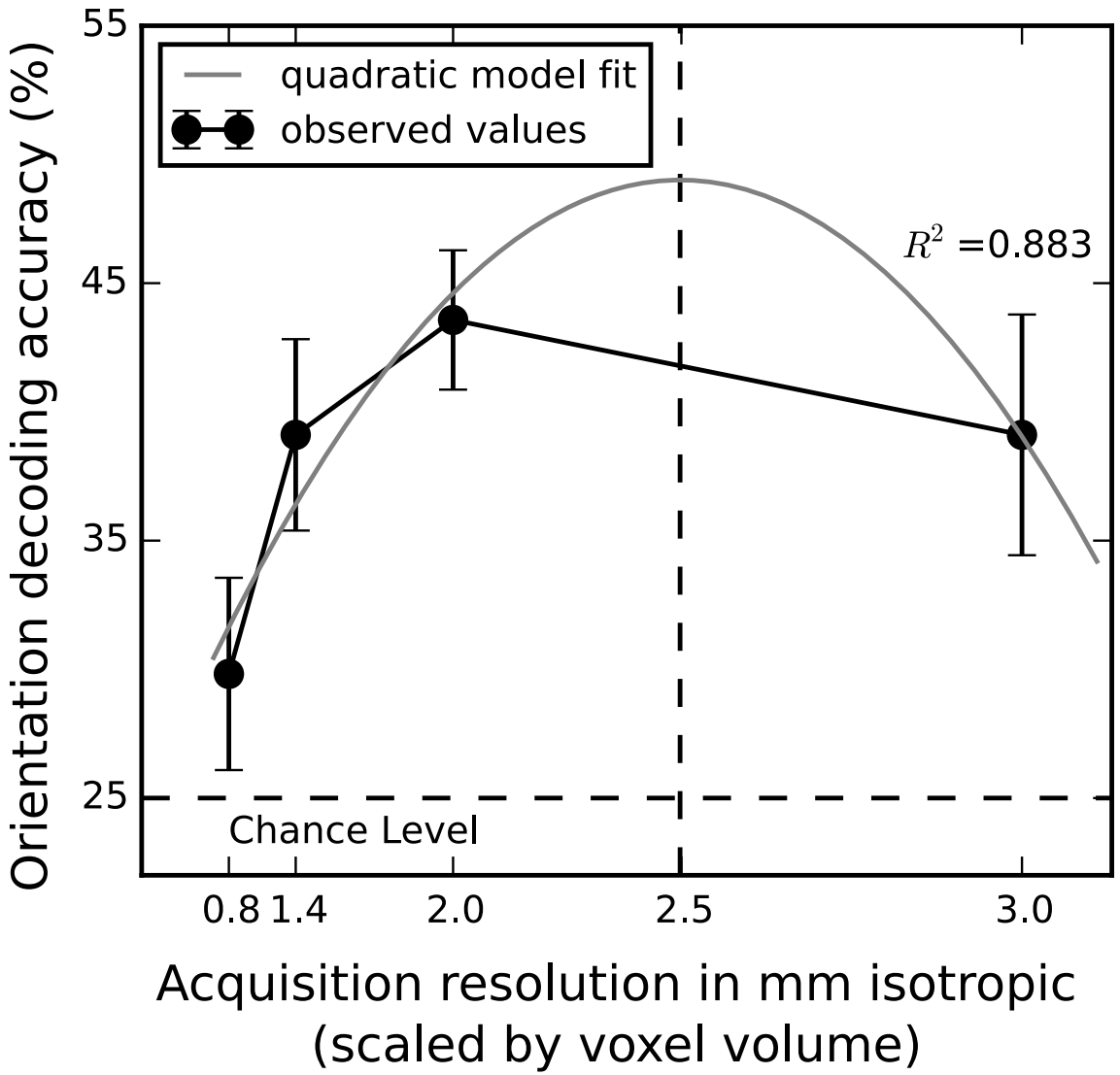
- Siemens 7 Tesla scanner with 32 channel head coil (Nova Medical, Wilmington, MA)
- T2*-weighted echo planar images (EPI) (TR/TE=2000/22 ms, FA=90°)
- Sequential acquisitions with 10% inter-slice gap parallel to calcarine sulcus (on a tilted axial plane)

Region of interest localization



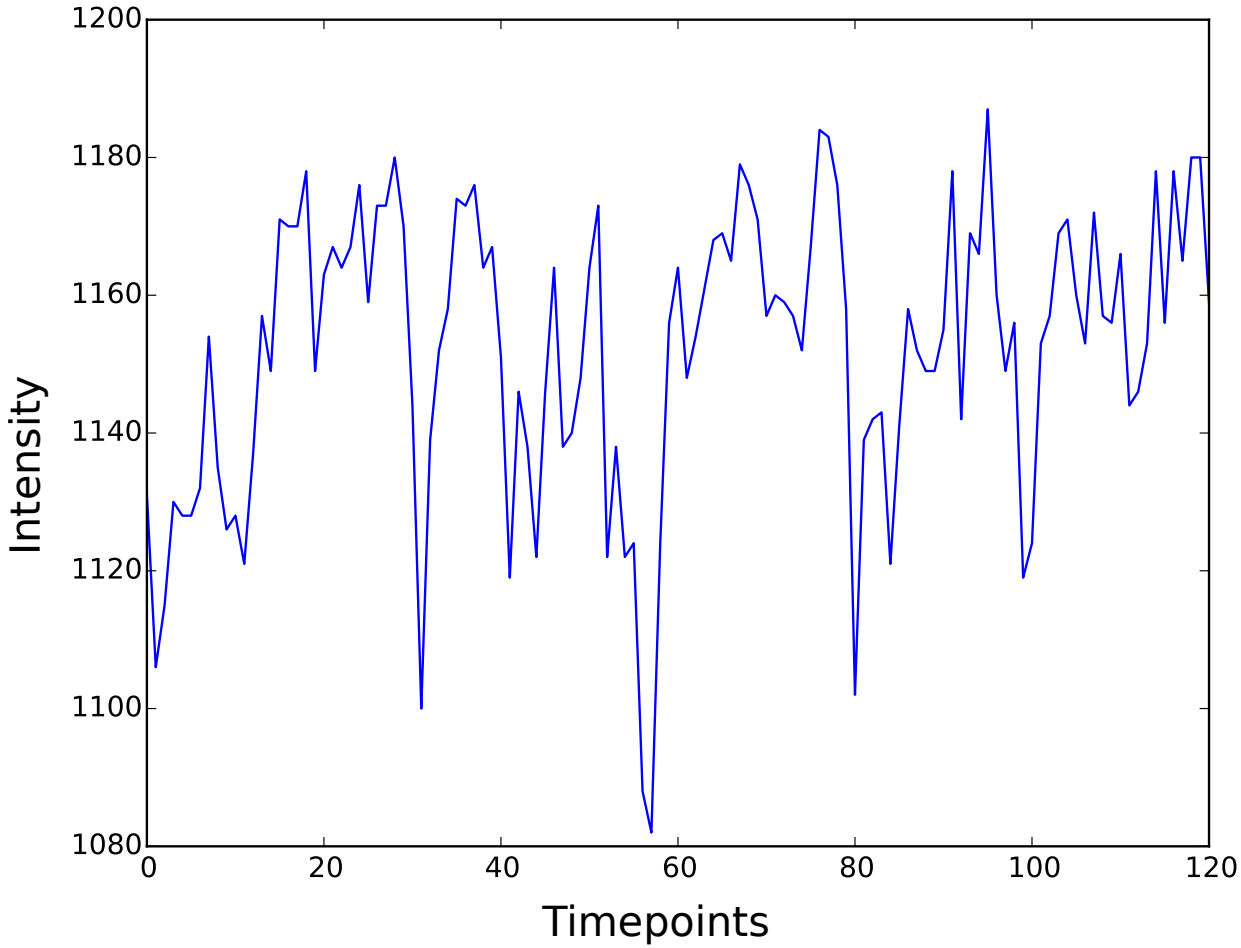
- Retinotopic mapping to delineate V1 region.
- Susceptibility weighted imaging to localize veins.

Classification Results (V1)

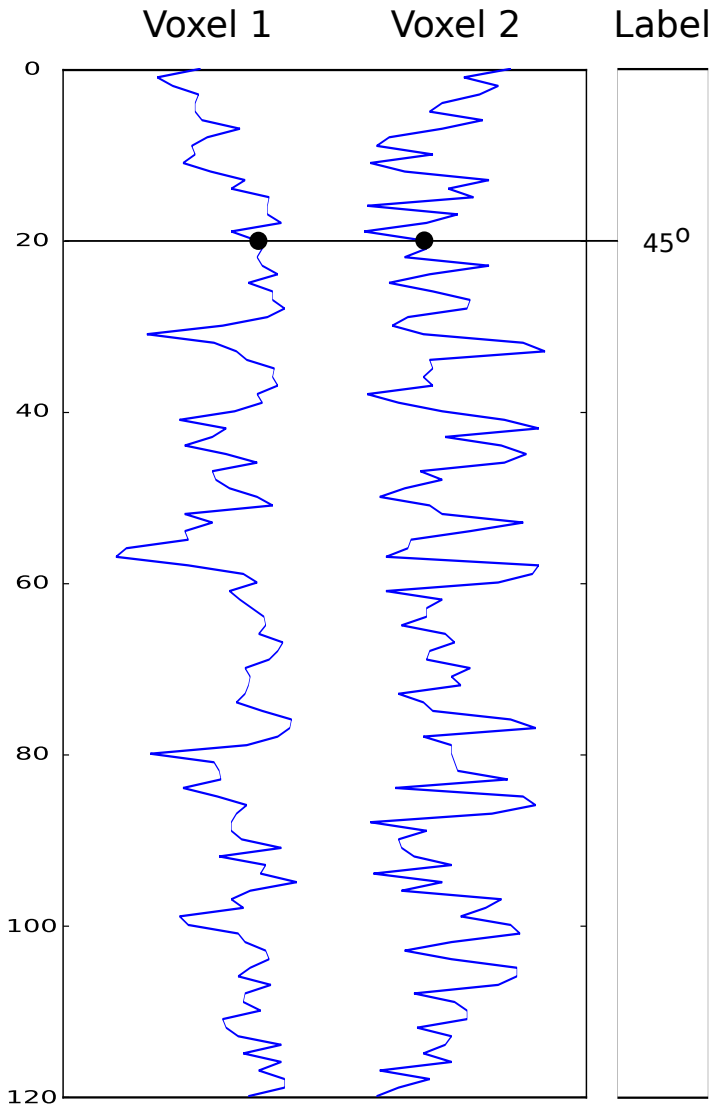


Classification / Orientation Decoding / MVPA
How was it performed ?

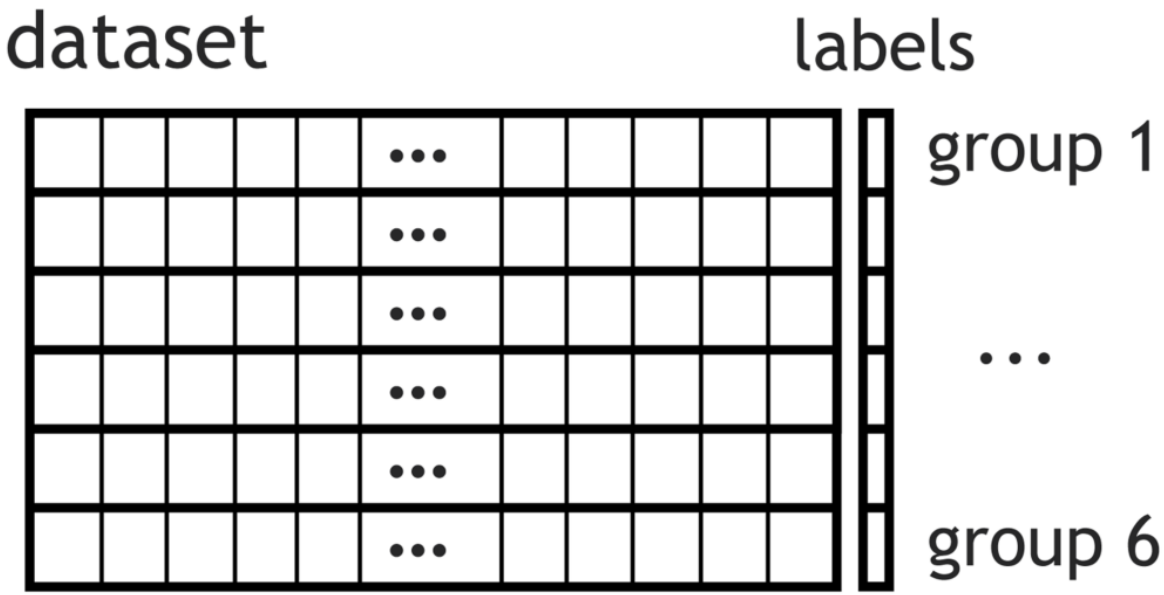
Voxel Timeseries



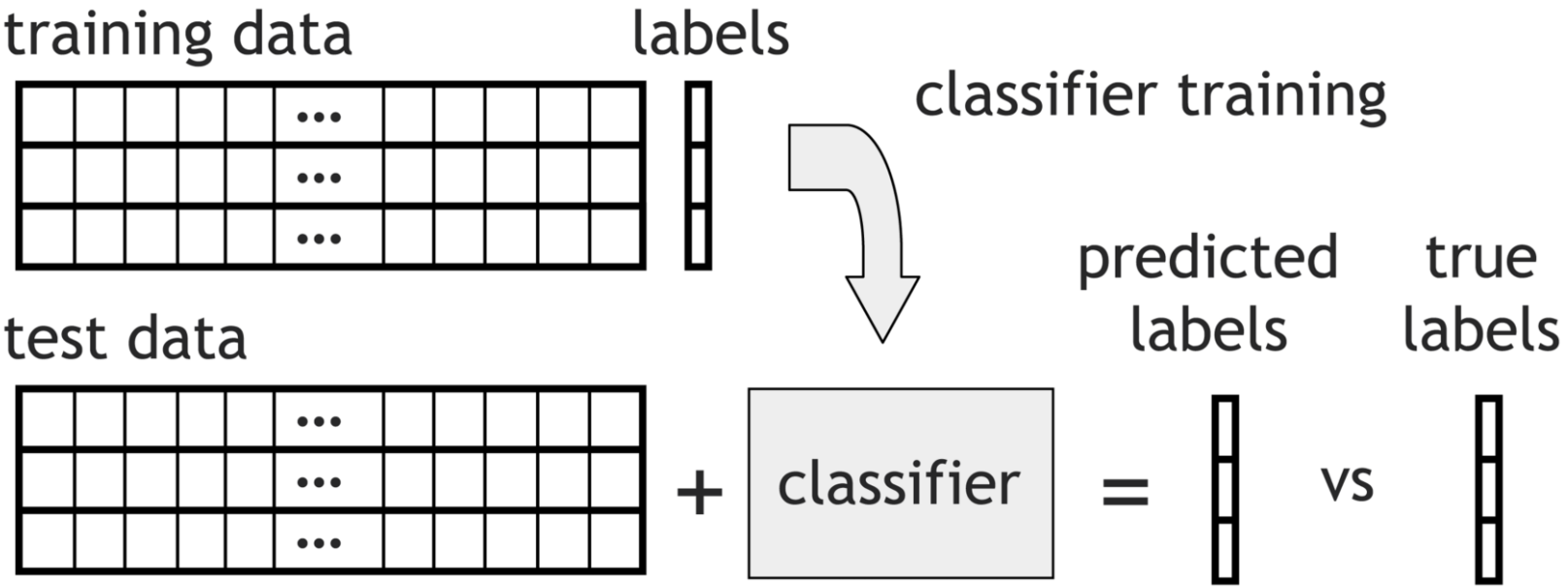
Voxel Timeseries to MVPA dataset



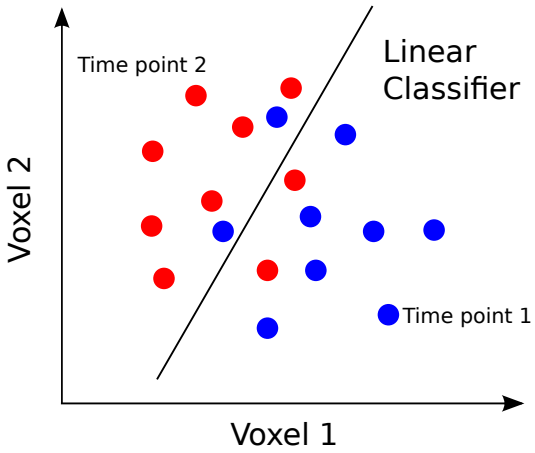
MVPA dataset

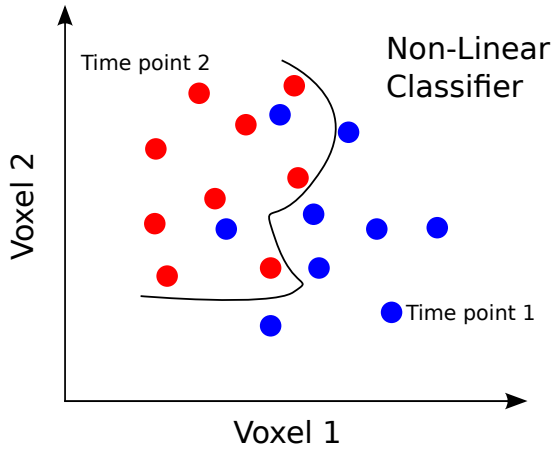


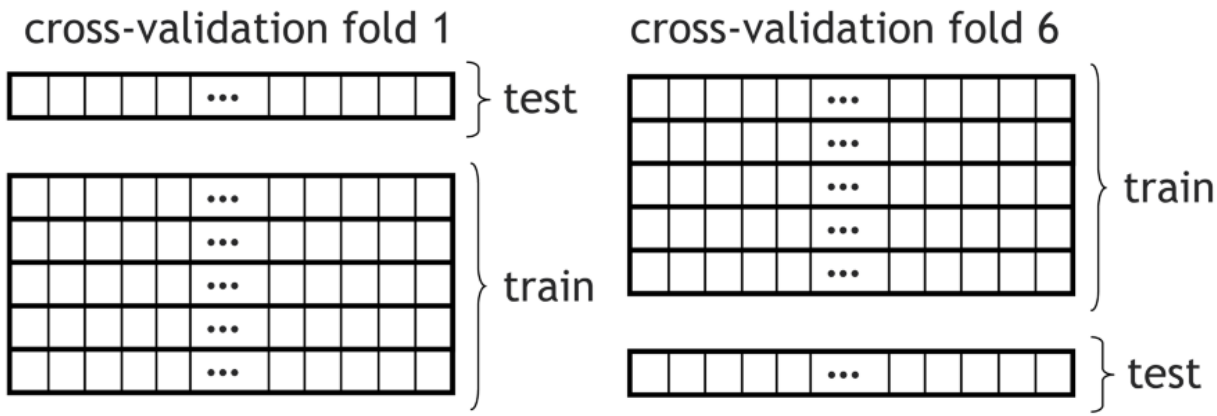
Classification Procedure



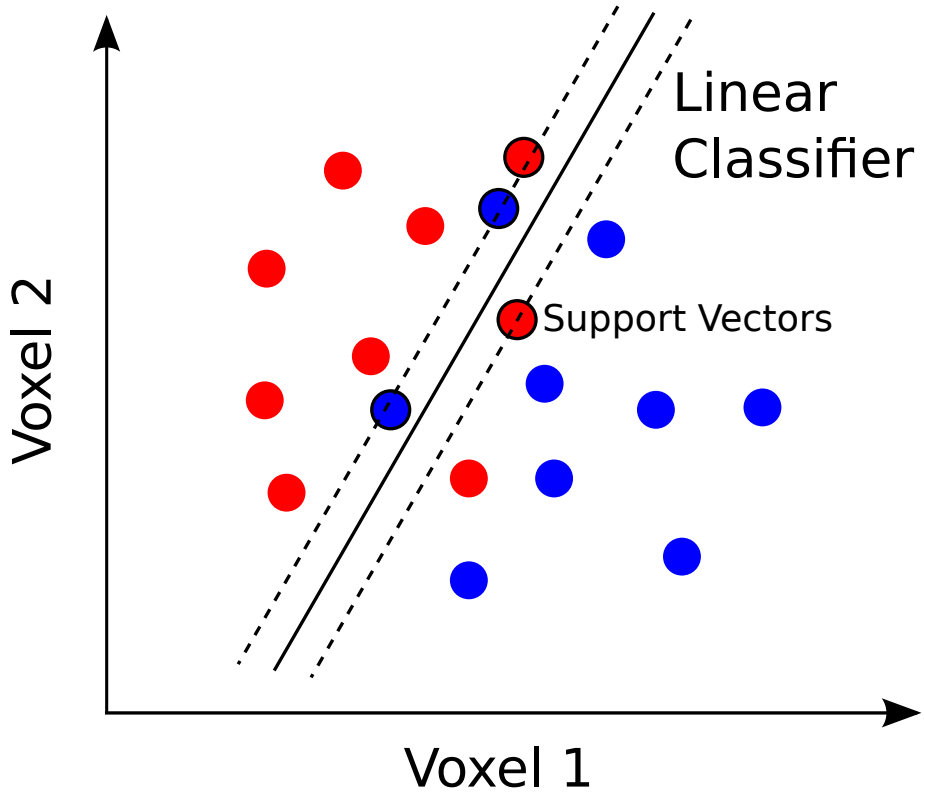
Cross Validation





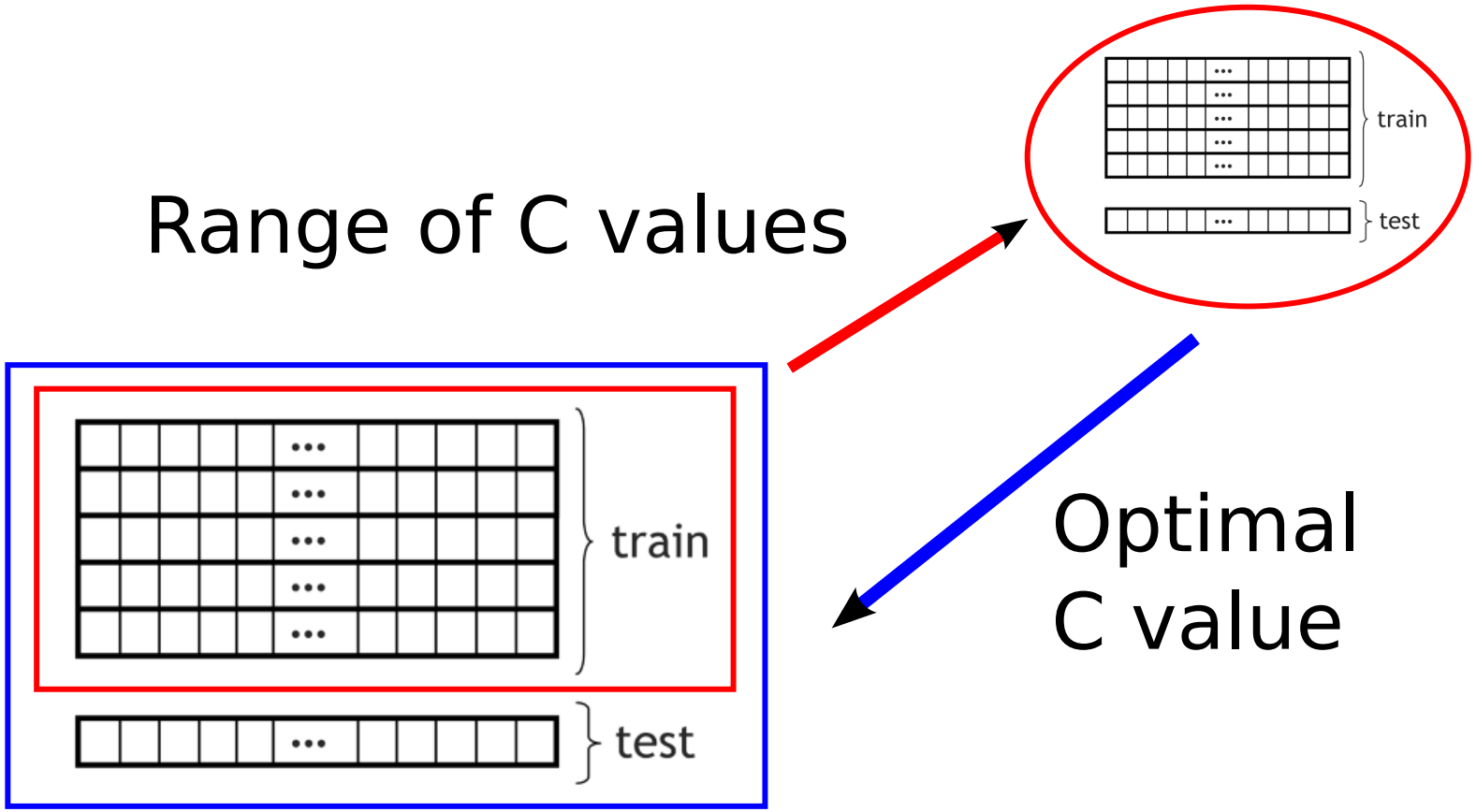


C parameter in LinearCSVM

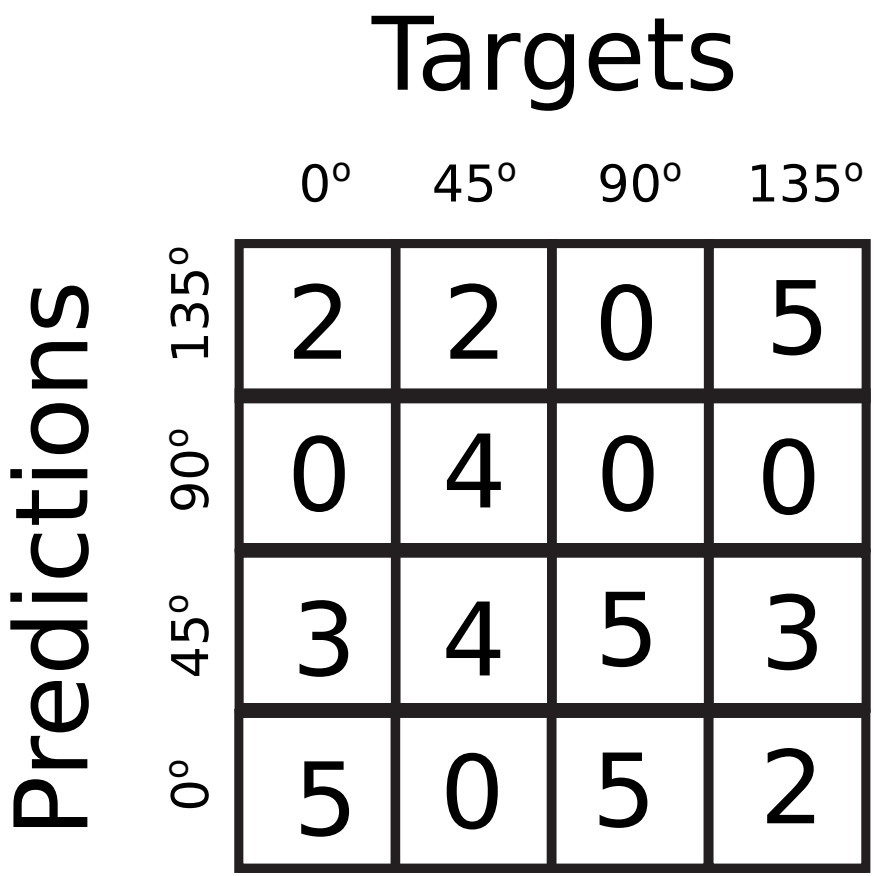


- C parameter - Trade-off parameter between margin width and number of support vectors.
- Higher C more rigid margin SVM.

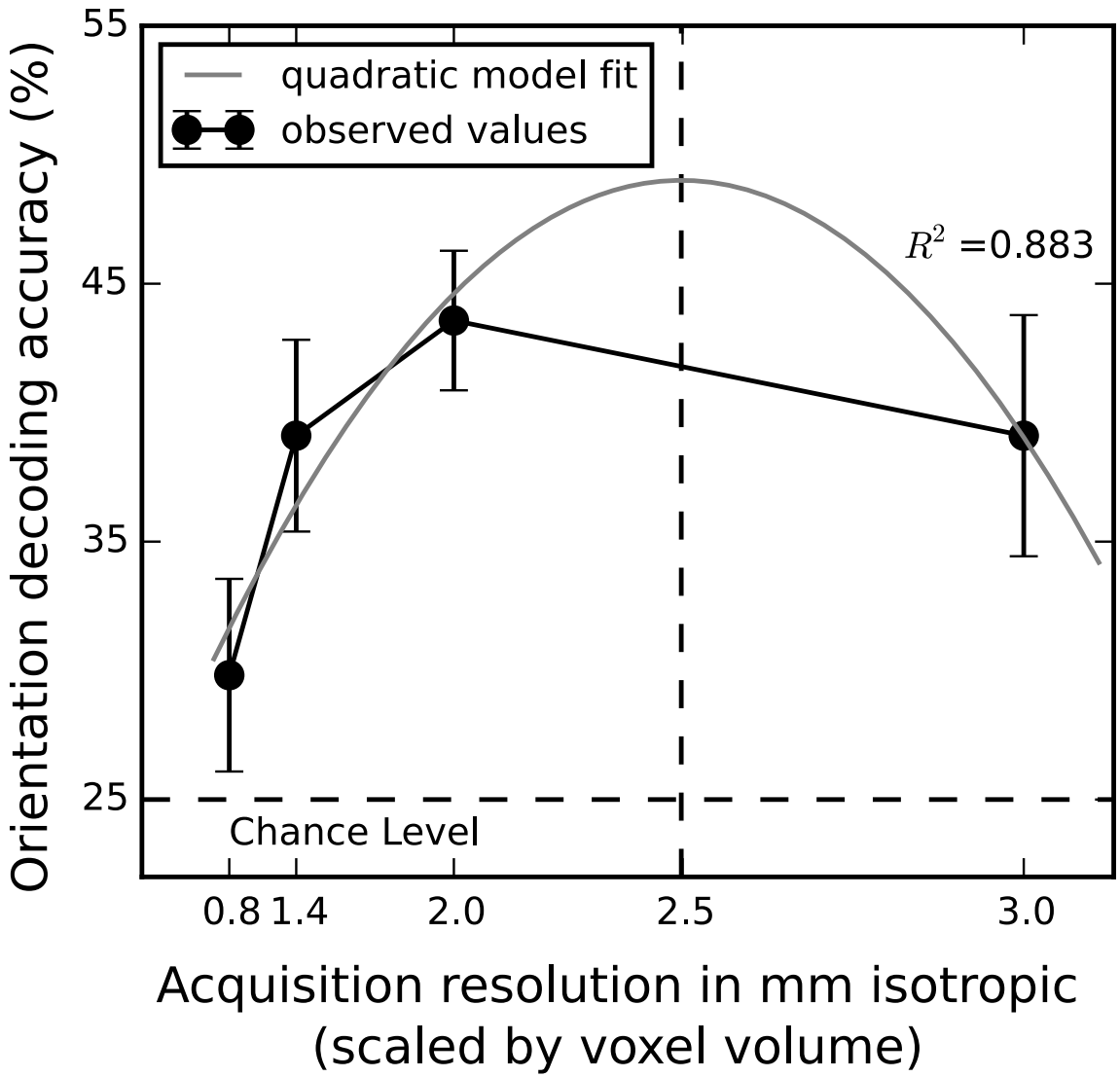
Nested Cross Validation



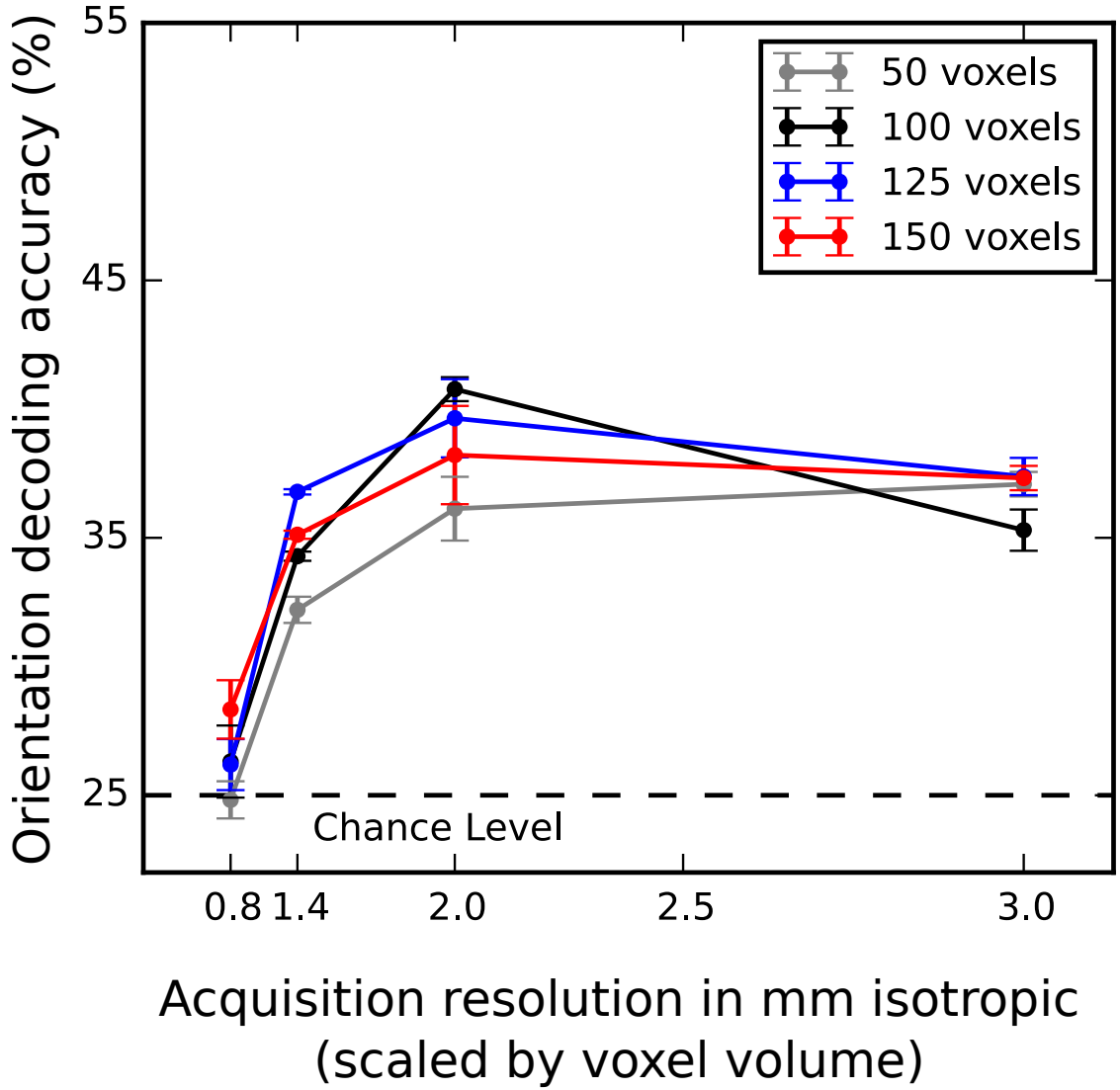
Confusion Matrix



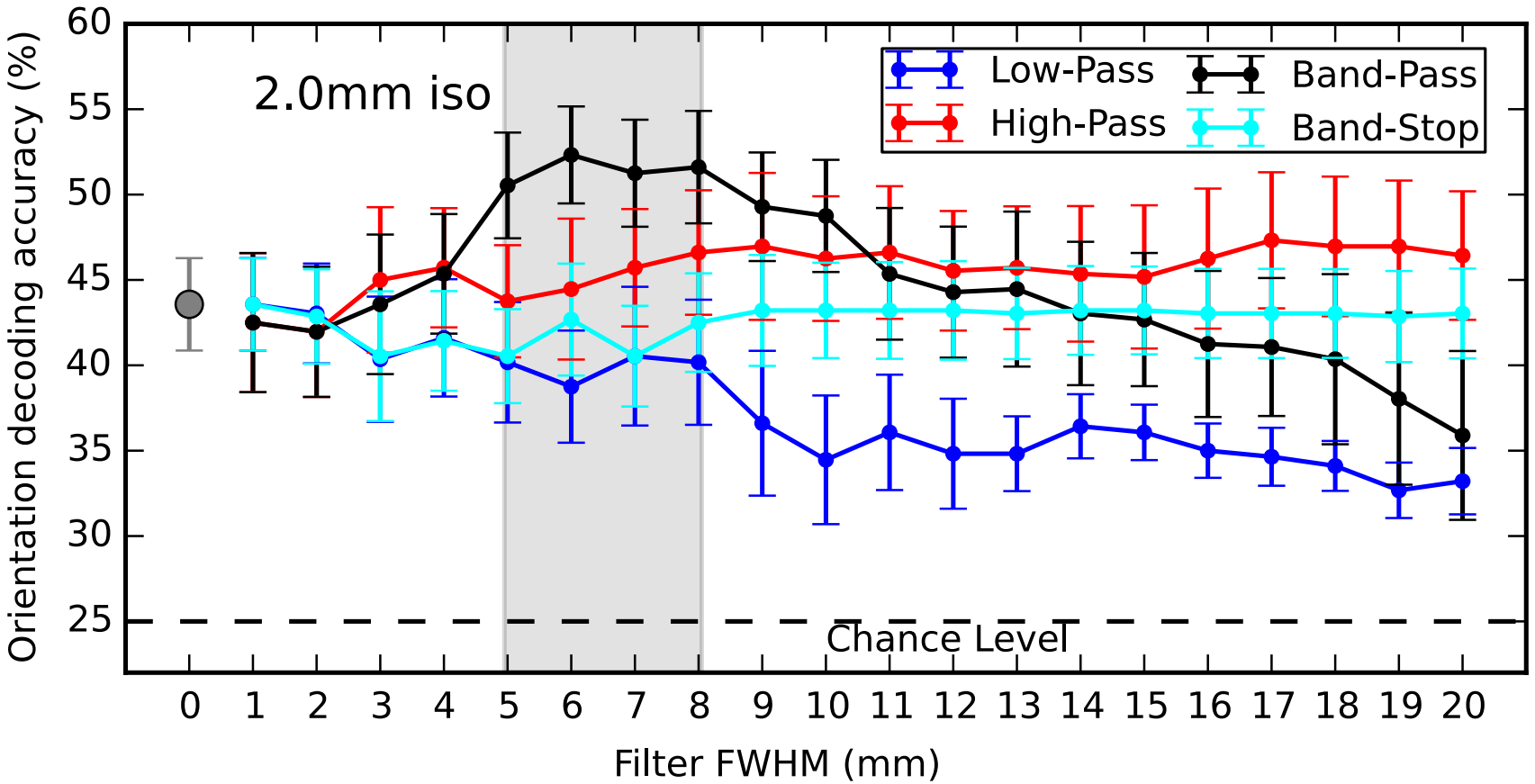
Classification Results (V1)



Classification Results (Fixed Number of Voxels)



Classification Results after Spatial Filtering



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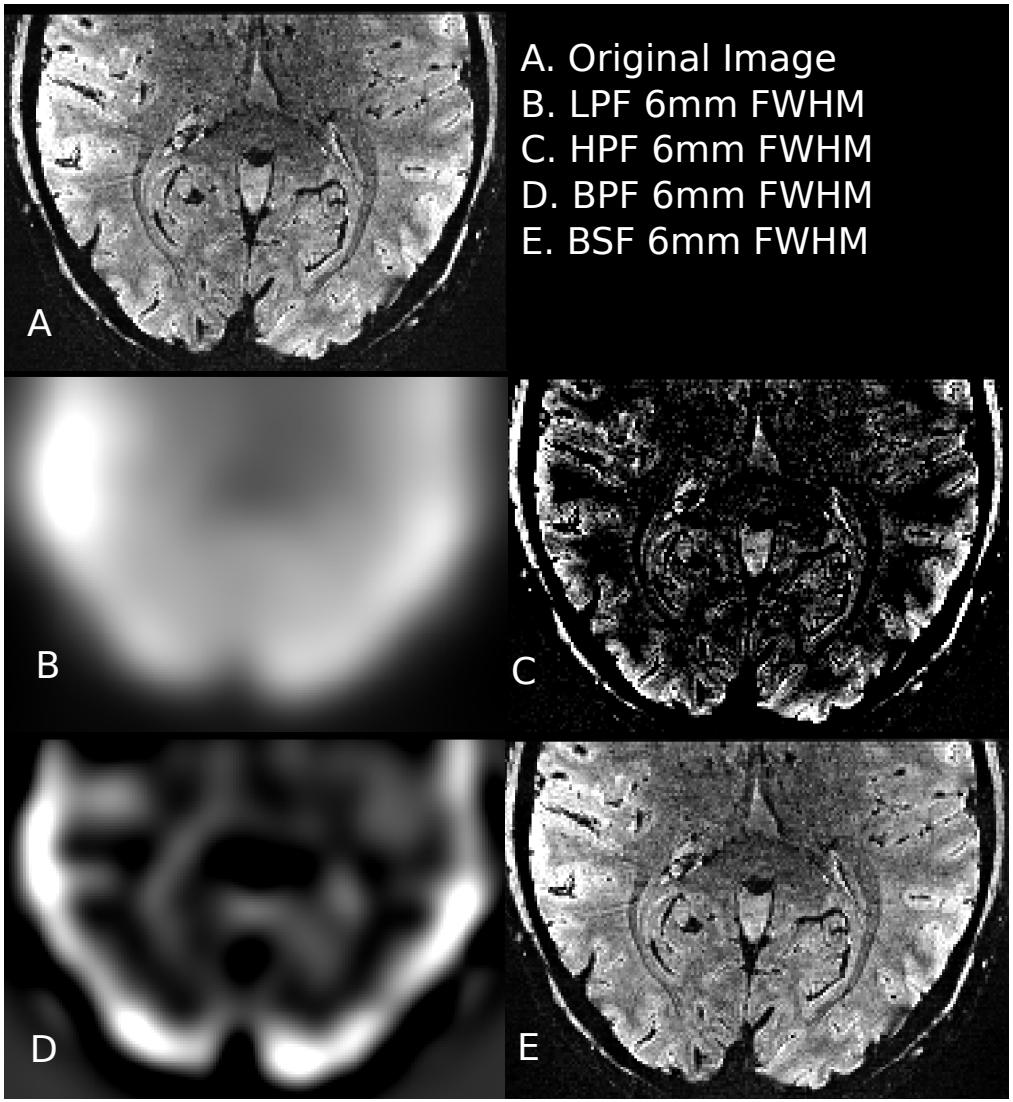

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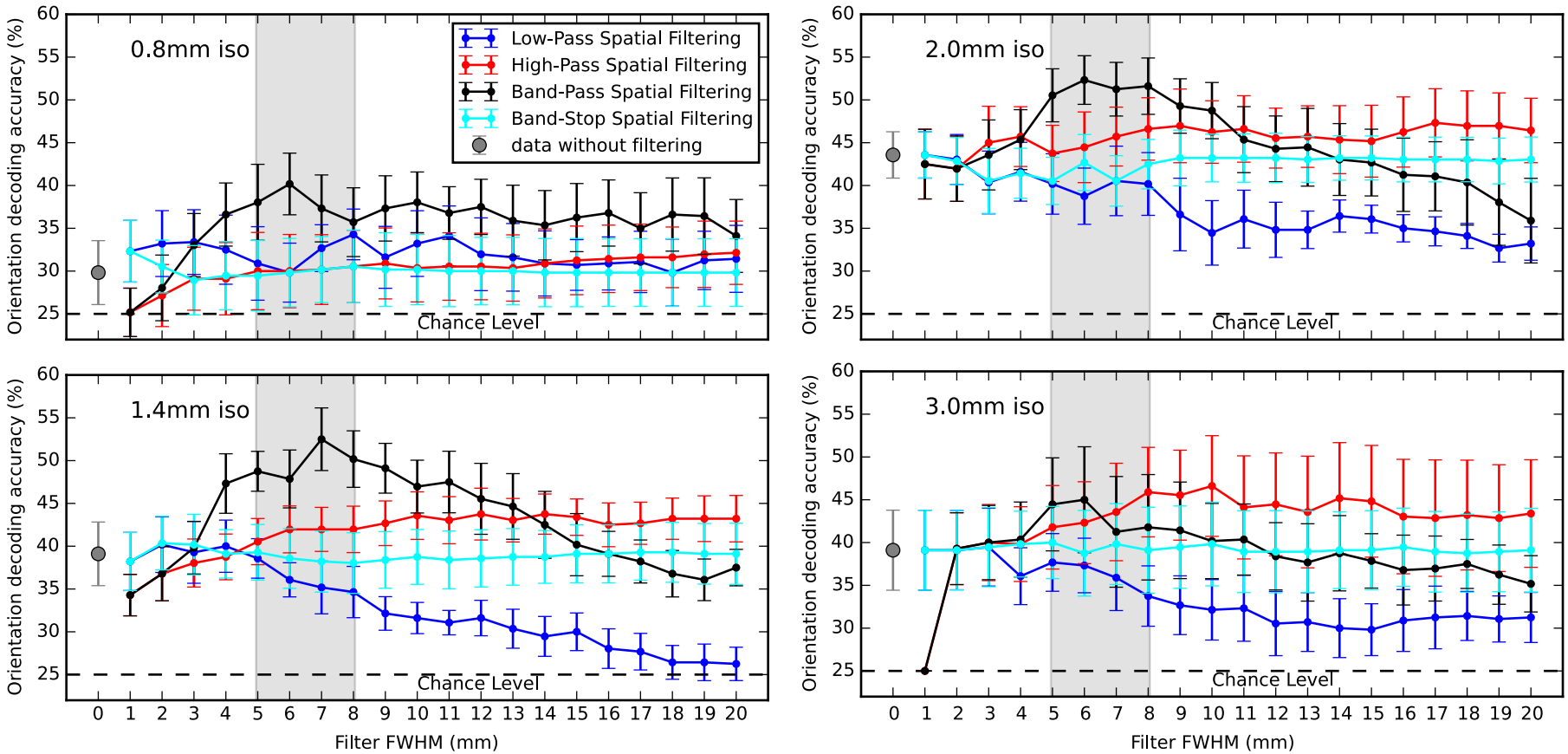
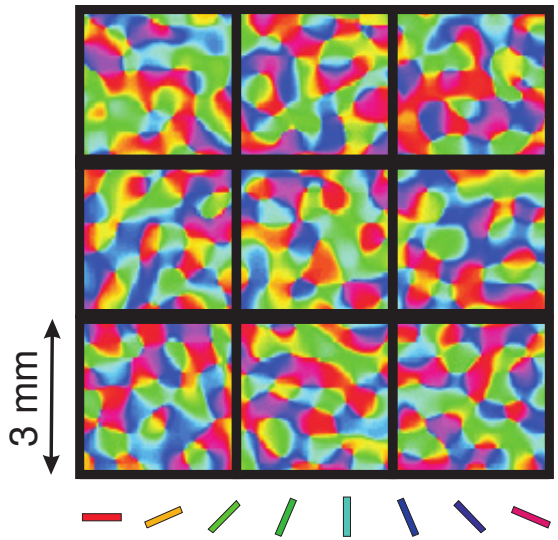
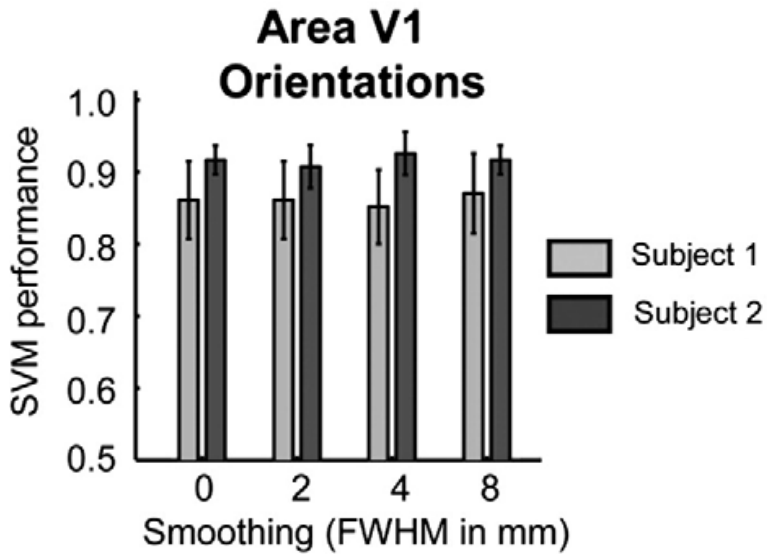


Spatial smoothing does not hurt Orientation decoding



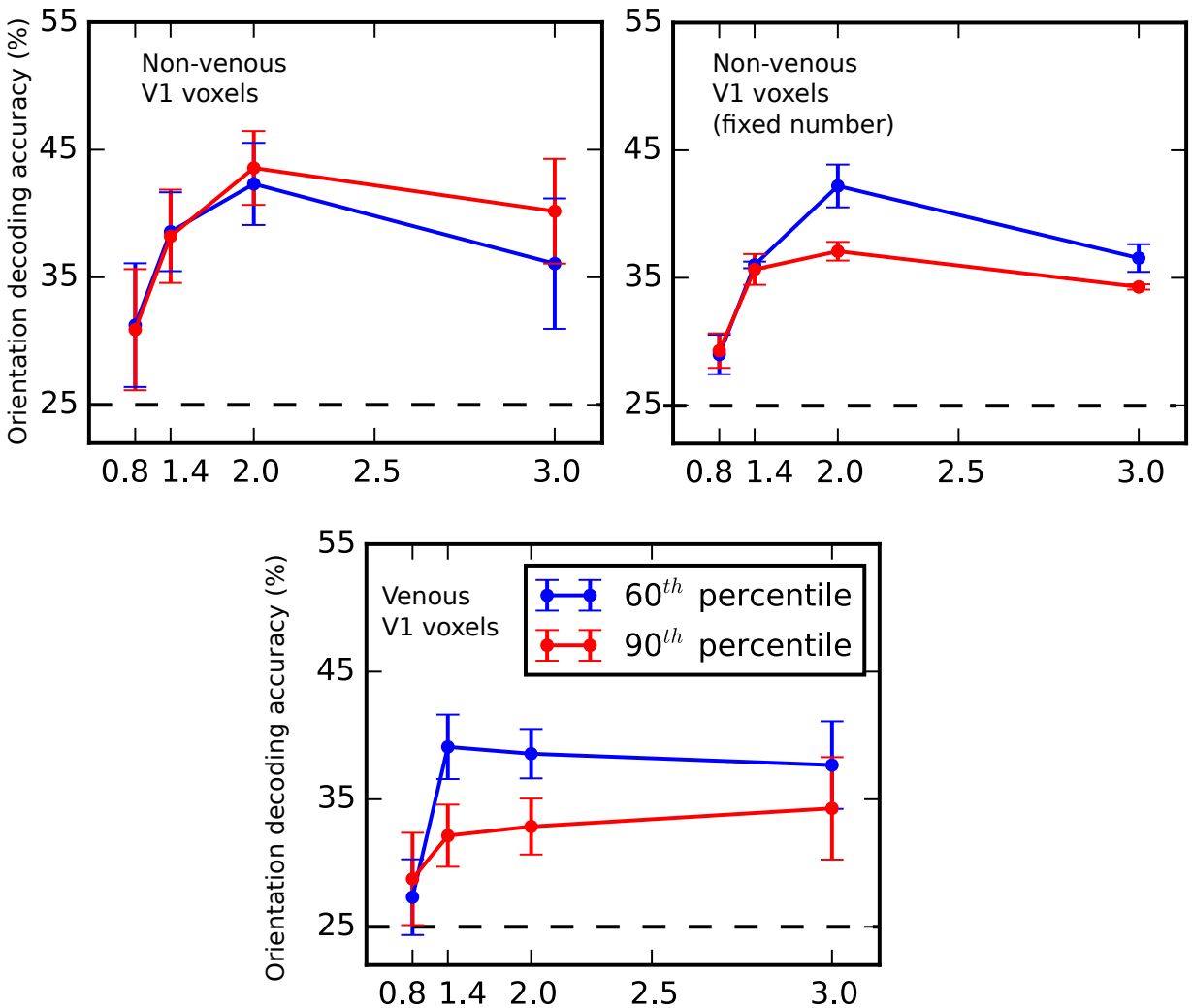
Boynton, 2005



Op de Beeck, 2010

- Reliable Orientation decoding is possible with 3mm iso voxel size. (Kamitani and Tong, 2005 and Haynes and Rees, 2005)
- Above chance level decoding could be performed after spatial Gaussian smoothing.

Contribution of veins to decoding



Acquisition resolution in mm isotropic (scaled by voxel volume)

Conclusions

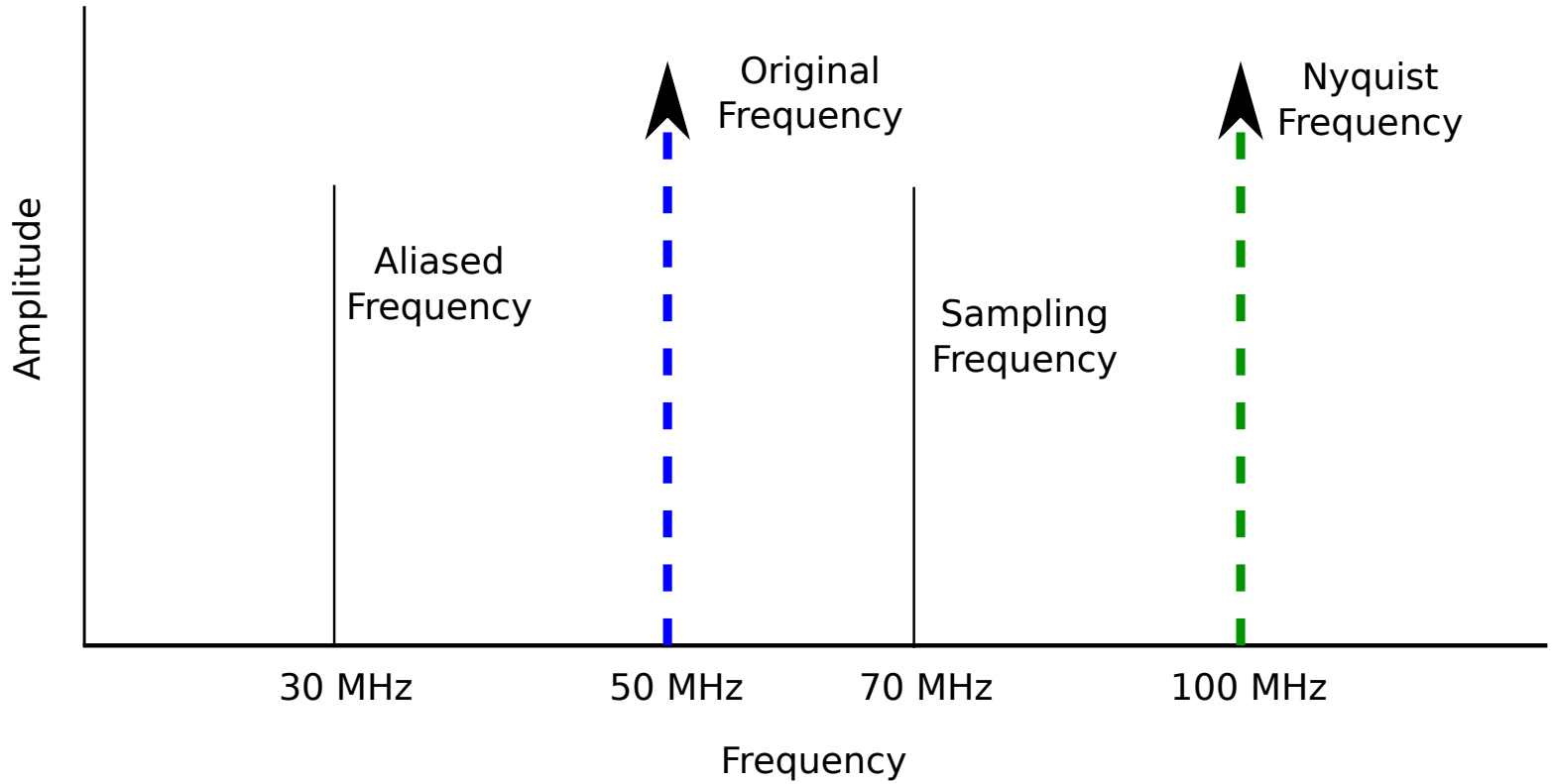
- Optimal Acquisition Resolution is $\approx$ 2.5mm iso.
- Aliasing is improbable. Highest accuracy of band-pass components $\approx$ 5-8mm FWHM for all resolutions.
- Low spatial frequency components contribute to noise.
- Veins carry little orientation specific signal.

Acknowledgements

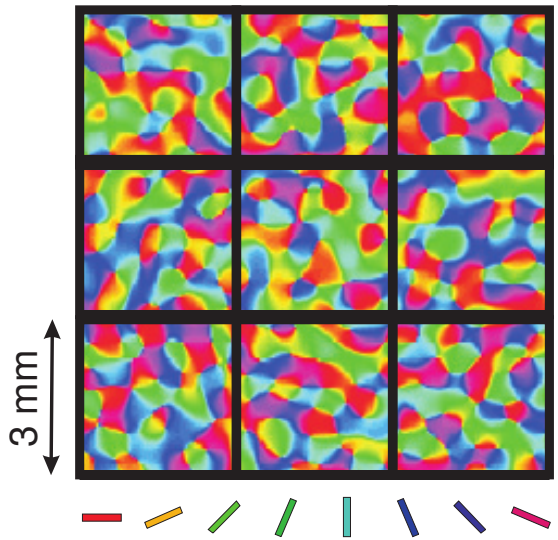
- Jun. Prof. Dr. Michael Hanke
- Renat Yakupov
- Prof. Dr. Stefan Pollmann
- Prof. Dr. Oliver Speck

Questions

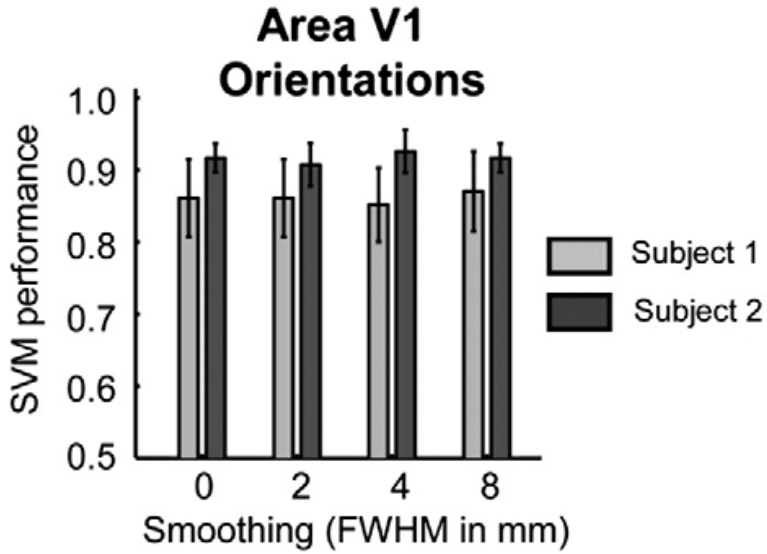
Discussion: Nyquist Sampling Theory



Discussion: Spatial smoothing does not hurt Orientation decoding



Boynton, 2005



Op de Beeck, 2010

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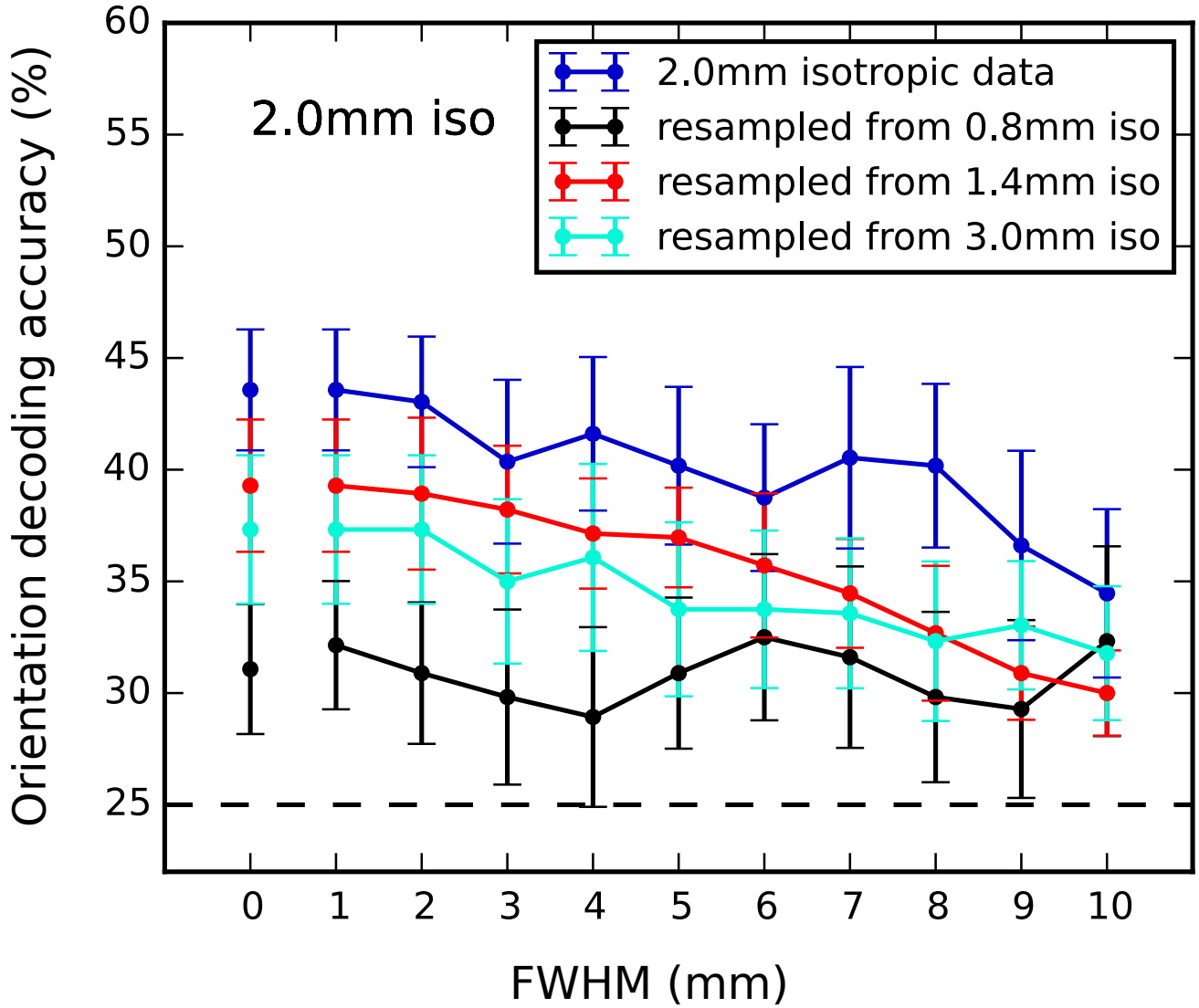
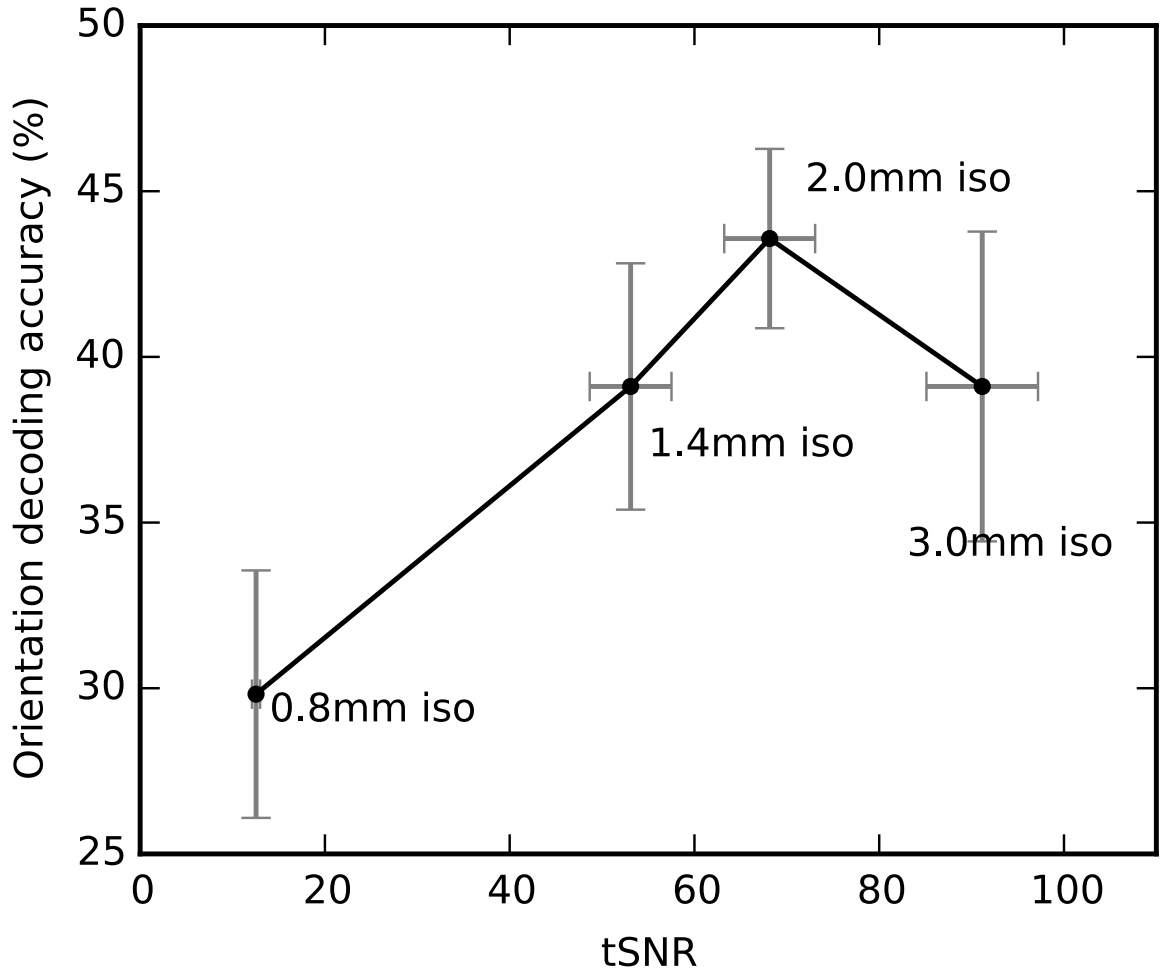
- Above chance level decoding could be performed after spatial Gaussian smoothing.

Discussion: Spatial Re-sampling to Other Resolutions



Dependence on temporal SNR



Mean Pecrentage BOLD signal change