A novel approach for the assessment of population receptive field mapping results

Allan Hummer [A], Markus Ritter [B], Michael Woletz [A], Maximilian Pawloff [B], Martin Tik [A], Ursula Schmidt-Erfurth [B], Christian Windischberger [A]

A. Center for Medical Physics and Biomedical Engineering, Medical University of Vienna, Vienna, Austria
B. Department of Ophthalmology and Optometry, Medical University of Vienna, Vienna, Austria

MEDICAL UNIVERSITY OF VIENNA

Introduction

Retinotopic maps estimated via population receptive field (pRF) mapping (Dumoulin et. al., 2008) are influenced by various factors, such as visual stimulus design, fMRI acquisition parameters, preprocessing, analysis and finally, thresholding. Thresholding should remove unreliable voxels, but still retain comprehensive pRF coverage of the visual field in healthy subjects. To this end, we herein suggest the use of "quiver plots" for visualising the stability of pRF mapping estimates between runs based on different thresholds of explained variance. We also compare pRF centres estimated from full stimulation runs and runs incorporating an artificial central scotoma of 4.7° radius.

Methods

- Six healthy subjects
  age: 25.8 ± 4.5 years; 3 female
- 3T Siemens TIM Trio scanner
- Flickering, traveling bar stimulus
  central visual field coverage of 18.8°
  full stimulation & artificial 4.7° scotoma
- Two functional runs per stimulus type
  CMRR multiband EPI, TE/TR = 36ms/1500ms,
  voxel size = 1mm³, 28 slices, 224 volumes per run
- T1-weighted anatomical scan
  MPRAGE, voxel size = 1mm³
- Anatomy segmented with Freesurfer
- Preprocessing and analysis performed with SPM12 and mrVista

Results

We created quiver plots by connecting estimated run #1 and #2 pRF centres of the same suprathreshold V1 voxels, where arrows indicate the direction of change.

- PRF estimation is more stable for higher variance explained thresholds as they lead to smaller average pRF centre distances
  0.98° ± 1.61° for var. exp. ≥ 0%, 0.54° ± 0.41° for var. exp >10% and 0.40° ± 0.26° for var. exp. >50%
- However, pRF coverage is reduced
- With artificial scotoma, most central voxels do not pass a var. exp. threshold of 10%
- Suprathreshold voxels are mostly assigned to peripheral locations

Conclusion

By transferring the estimated pRF parameters back to visual field space, results are being compared in a common frame of reference. Quiver plots can not only help to determine the optimal threshold of explained variance, but also allow for the assessment of pRF parameter estimation stability and possible systematic differences related to factors such as stimulus, fMRI sequence, preprocessing and pRF analysis.

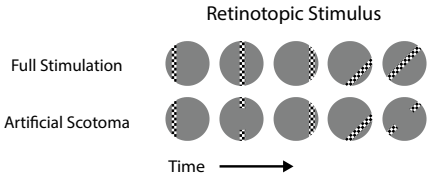

Figure 1. During fMRI measurements a flickering bar was shown, which crossed the visual field in eight different directions. For the runs incorporating an artificial scotoma, the central 4.7° visual angle remained grey during the entire time.

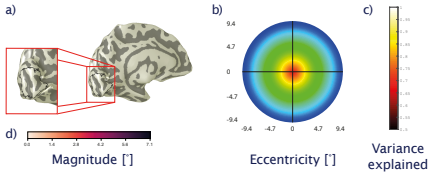

Figure 2. Illustration of a) the inflated anatomy mesh of the subject's left visual cortex, b) the eccentricity parameter colour circle, c) the colour bar of the visual field coverage maps and d) the colour bar of the quiver plots shown in Figures 3 to 8.

Run 1 vs Run 2

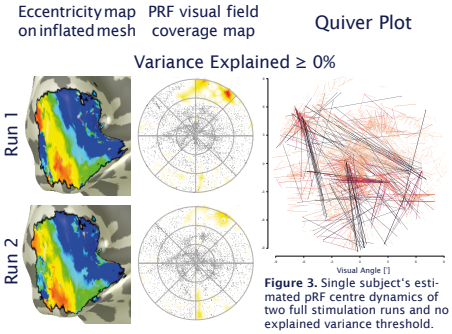

Figure 3. Single subject's estimated pRF centre dynamics of two full stimulation runs and no explained variance threshold.

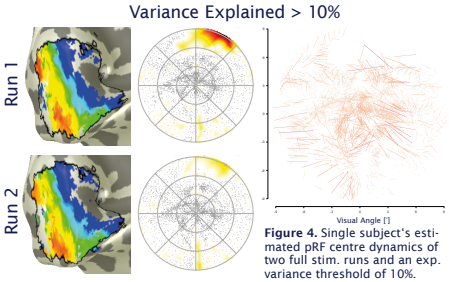

Figure 4. Single subject's estimated pRF centre dynamics of two full stim. runs and an exp. variance threshold of 10%.

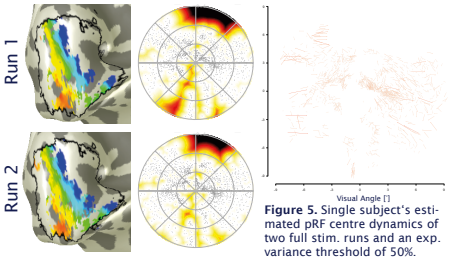

Figure 5. Single subject's estimated pRF centre dynamics of two full stim. runs and an exp. variance threshold of 50%.

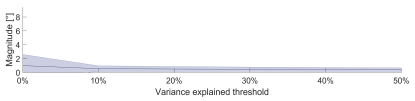

Figure 9. Average quiver magnitude and standard deviation decrease for higher thresholds of explained variance, which leads to increased stability across runs.

Full Stim. vs Artificial Scotoma

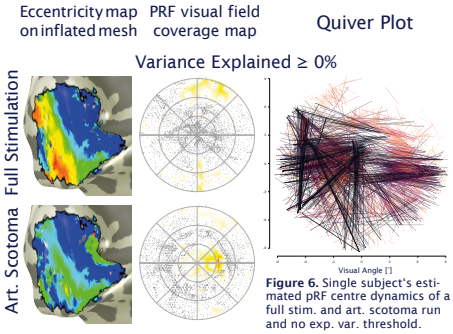

Figure 6. Single subject's estimated pRF centre dynamics of a full stim. and art. scotoma run and no exp. var. threshold.

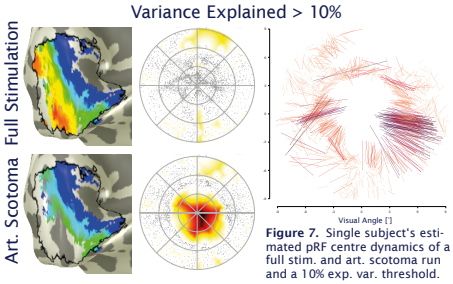

Figure 7. Single subject's estimated pRF centre dynamics of a full stim. and art. scotoma run and a 10% exp. var. threshold.

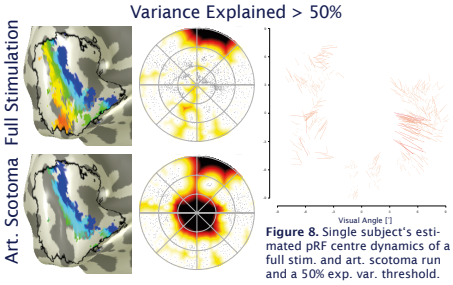

Figure 8. Single subject's estimated pRF centre dynamics of a full stim. and art. scotoma run and a 50% exp. var. threshold.

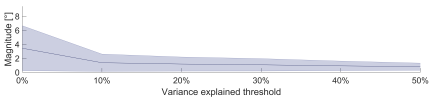

Figure 10. Although considerably larger when compared to two runs of the same stimulus, average quiver length and standard deviation decrease for higher thresholds of explained variance.

Corresponding Author Contact
allan.hummer@meduniwien.ac.at
www.fmri.at

References

Dumoulin, S. O. (2008), Population receptive field estimates in human visual cortex, *Neuroimage*, vol. 39(2), pp. 647-660
Haak, K. V. (2012), Population receptive field dynamics in human visual cortex, *PLoS ONE*, vol. 7(5), pp. e37686
Hummer, A. (2018), Artificial scotoma estimation based on population receptive field mapping, *Neuroimage*, vol. 169, pp. 342-351