OCT results corroborate population receptive field maps in patients with retinal disease

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Introduction

Functional magnetic resonance imaging (fMRI) can be used for population receptive field (pRF) mapping [1] of the visual cortex. It is an ideal method for obtaining detailed retinotopic information in healthy subjects and patients suffering from retinal disease. In a preceding study, the ability to estimate scotomata of Stargardt's disease (STGD) and Retinitis Pigmentosa (RP) patients using pRF mapping was compared to microperimetry (MP) results [2]. Herein we extend our results by assessing the comparability of pRF maps to data obtained from optical coherence tomography (OCT).

Methods

Eight STGD patients (age: 34.6 ± 18.7 years; 7 female) and eight RP patients (age: 41.8 ± 6.5 years; 5 female) were scanned with the CMRR EPI MB sequence (TE/TR=36ms/1500ms, MB factor = 2, voxel size = 1mm^3) on a SIEMENS 3T Trio scanner. They were presented with a visual stimulus consisting of a moving, flickering checkerboard bar. Preprocessing was performed with SPM12, while Freesurfer was used to segment an MPRAGE scan. PRF mapping was performed using mrVista and thresholded at 10% explained variance. Based on this data, PRF coverage maps were created and binarised by thresholding at a value of 0.7. Patients were also examined using spectral-domain OCT (SDOCT, Heidelberg SPECTRALIS). SDOCT volume scans were imported into in-house software, enabling grading of areas with loss of outer retinal layers in B-scans and computing of planimetric measurements in complete volume scans. Correlation of SDOCT and pRF maps was evaluated using the simple matching coefficient (SMC).

Patient 1

- Female
- 18 years
- Stargardt's disease
- Left eye
- Visual acuity: 0.5 LogMAR

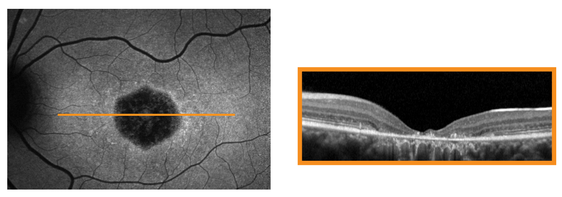

Figure 1. Fundus auto fluorescence (left) with central SDOCT B-scan (right).

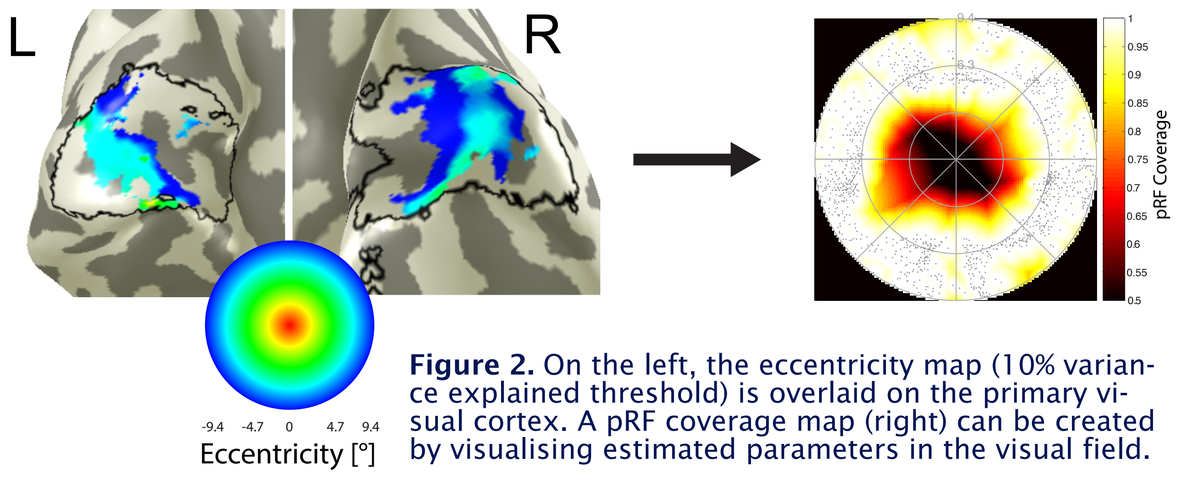

Figure 2. On the left, the eccentricity map (10% variance explained threshold) is overlaid on the primary visual cortex. A pRF coverage map (right) can be created by visualising estimated parameters in the visual field.

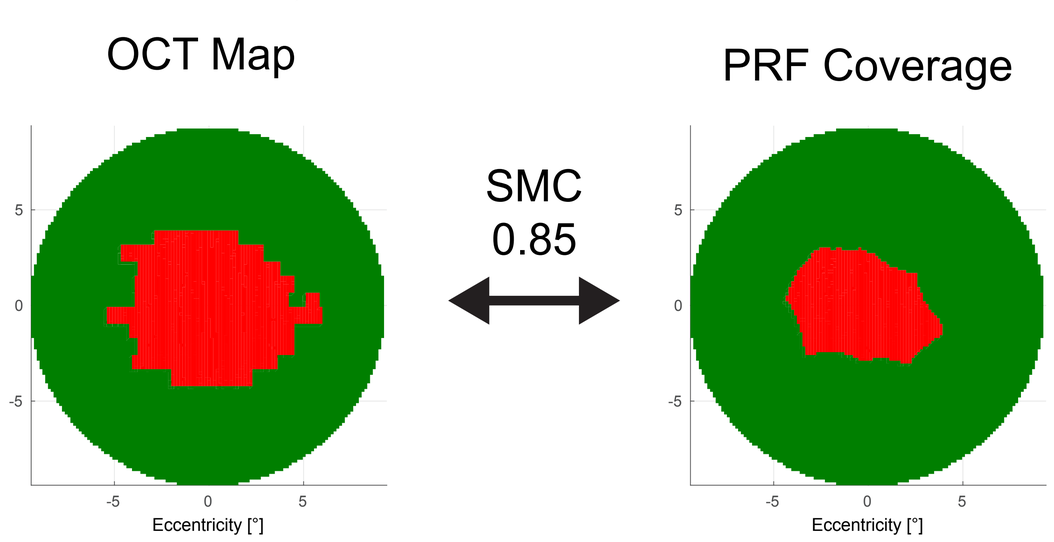

Figure 3. Correspondence of graded SDOCT maps and pRF coverage maps. Red represents loss of outer retinal layers for the OCT map and pRF coverage ≤ 0.5 for the pRF coverage map, while green represents intact retinal tissue and pRF coverage > 0.5. To quanitfy correlation, the SMC was computed by dividing the number of identical by the number of total image pixels.

Patient 2

- Female
- 21 years
- Stargardt's disease
- Right eye
- Foveal sparing
- Visual acuity: 0.1 LogMAR

Figure 4. Fundus auto fluorescence (left) with central SDOCT B-scan (right). Foveal sparing is marked by the arrow.

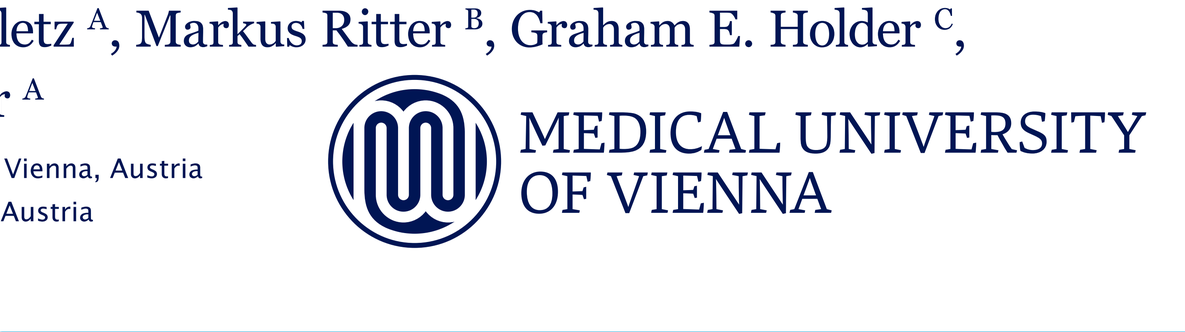

Figure 5. On the left, the eccentricity map (10% variance explained threshold) is overlaid on the primary visual cortex. A pRF coverage map (right) can be created by visualising estimated parameters in the visual field.

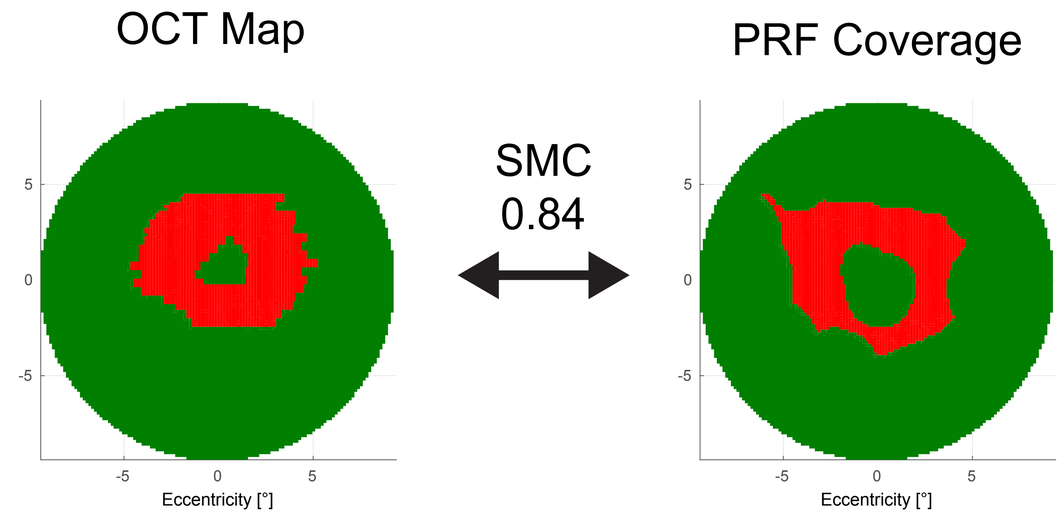

Figure 6. Correspondence of graded SDOCT maps and pRF coverage maps. Red represents loss of outer retinal layers for the OCT map and pRF coverage ≤ 0.5 for the pRF coverage map, while green represents intact retinal tissue and pRF coverage > 0.5. To quanitfy correlation, the SMC was computed by dividing the number of identical by the number of total image pixels.

Results

Central macular regions in STGD patients with loss of outer retinal layers correlated well with pRF coverage maps (mean SMC 0.84, SD ± 0.05). Both approaches clearly delineate pathological areas. Central loss of function can be seen in OCT and coverage maps as well as in the retinotopic maps overlaid on the visual cortex, where voxels did not explain sufficient variance near the occipital pole. In the patient with foveal sparing the preserved central function is also visible in the OCT, pRF coverage maps and retinotopic maps on the cortex. Patients with RP (not shown) exhibited concentric visual field defects in pRF maps. Functional losses were less pronounced compared to SDOCT results (mean SMC 0.39, SD ± 0.18).

Conclusion

Here we show for the first time that pRF maps acquired by fMRI match the results from OCT in patients suffering from retinal diseases. Our results indicate that retinotopic mapping provides a valuable adjunct to conventional methods when assessing retinal disease. PRF maps do not only correlate well with visual field tests, such as MP [2], but also with structural retinal imaging. The addition of pRF maps to OCT data allowed for objective assessment of retinal dysfunction almost independent of patient compliance.

References

[1] Dumoulin, S.O. (2008), Population receptive field estimates in human visual cortex *Neuroimage*, vol. 39(2), pp. 647-660

[2] Ritter, M. (2019), Correspondence between retinotopic cortical mapping and conventional functional and morphological assessment of retinal disease British Journal of Ophthalmology, vol 103(2), pp. 208-215

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