The relationship between cortical receptive field size and eccentricity in V1, V2, and V3 of healthy individuals

Melissa E Wright,[1a,b,c] Simon K Rushton,[1b] Krishna D Singh,[1b,c]
D Samuel Schwarzkopf,[2] Tony Redmond[1a]

[1]Cardiff University, Cardiff, UK; [a]School of Optometry and Vision Sciences, [b]School of Psychology, [c]Cardiff University Brain Research Imaging Centre (CUBRIC)

[2]Optometry and Vision Science, University of Auckland, Auckland, New Zealand

Purpose: In functional Magnetic Resonance Imaging (fMRI), a population receptive field (pRF) can be defined as the area of visual field to which all the neurons within a voxel respond to. The cortical representation of the central visual field has been very well documented, with pRF size increasing with eccentricity (i.e. distance from fixation) and between visual areas (e.g. V1-3). However, less is known about peripheral vision, which constitutes a large portion of our useful visual field and is primarily affected in conditions such as glaucoma. In this study, we utilise high-field 7T fMRI to extend current visual pRF maps into the mid-periphery in multiple cortical hierarchies.

Materials and Methods: pRF size was measured in 27 healthy individuals (sixteen female, 11 male; median [IQR] age: 19.80 [19.43 20.58] years; median [IQR] mean deviation: -0.89 [-1.34 -0.55] dB) with high-field 7T fMRI, allowing fine spatial resolution (1mm^3). Here, pRFs were measured in central (0-6° eccentricity) and peripheral (14-18° eccentricity) regions relating to the inferior temporal visual field. Visual areas V1-V3 were manually delineated per participant using retinotopic maps, owing to between-subject variation, and used as masks to extract cortical pRF size. The association between pRF size and eccentricity was investigated.

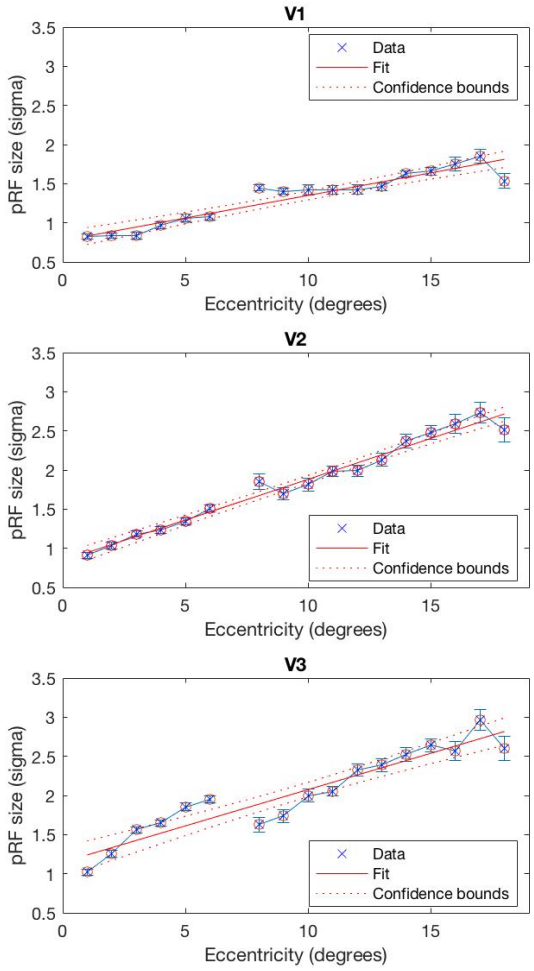

Figure 1: pRF size as a function of eccentricity in V1 (top), V2 (middle), and V3 (bottom)

Results: As previously reported, there is a positive association between pRF size and eccentricity in the central visual field in visual area V1-V3. This association continues into the peripheral locations (see figure 1). The slope and intercept of the relationship between pRF size and eccentricity were slightly greater with higher visual areas (V1 = 0.06 [intercept = 0.77, R^2 = 0.90]; V2 = 0.10 [intercept = 0.84, R^2 = 0.98]; V3 = 0.09 [intercept = 1.15, R^2 = 0.89], all $p<0.01$). Variability in the relationship also increases with higher visual areas (root-mean-square error: V1 = 0.10; V2 = 0.09; V3 = 0.18).

Conclusions: This is the first study to report the effect of eccentricity on pRF size beyond the central visual field in multiple cortical hierarchies. pRF size continues to increase into the peripheral visual field, but notable variance is apparent in the data. Establishing normal values for pRF size is important to better understand how visual stimuli are processed throughout the whole visual pathway, and also provide a reference for future studies into peripheral visual function in health and disease.