Decoding and reconstructing color from responses in human visual cortex

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Supplementary Figures

Gijs Joost Brouwer and David J. Heeger

Department of Psychology and Center for Neural Science, New York University, New York, New York 10003

Corresponding author

Gijs Joost Brouwer

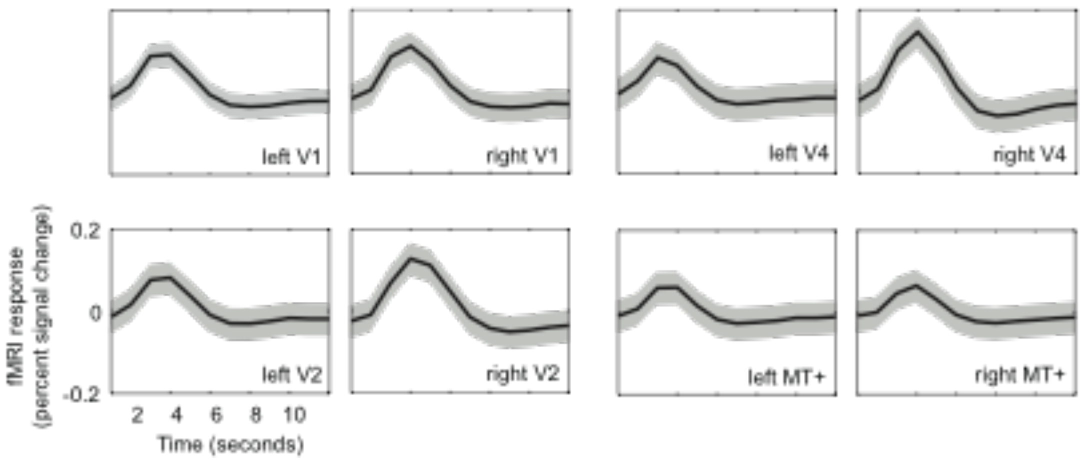
Department of Psychology and Center for Neural Science,

New York University,

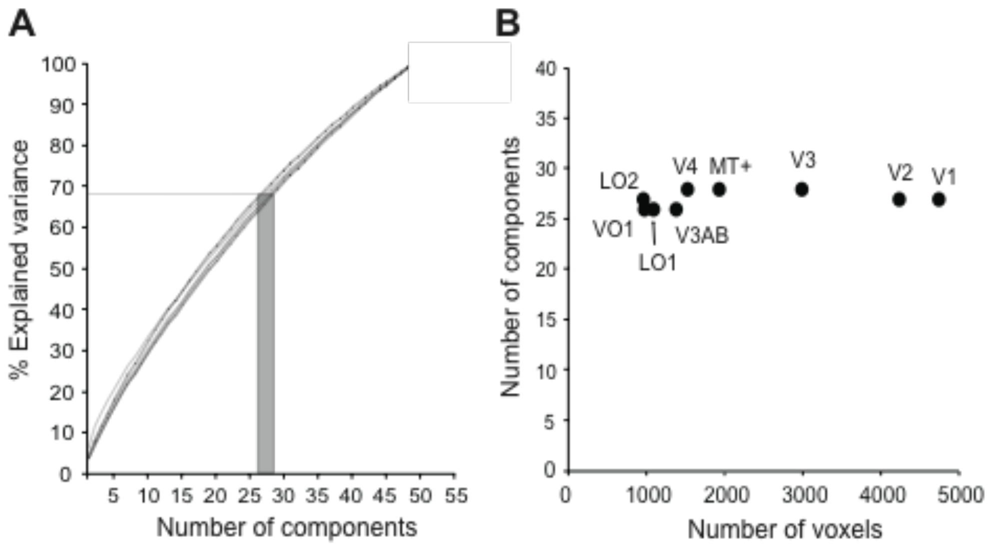
New York, New York, 10003

United States of America

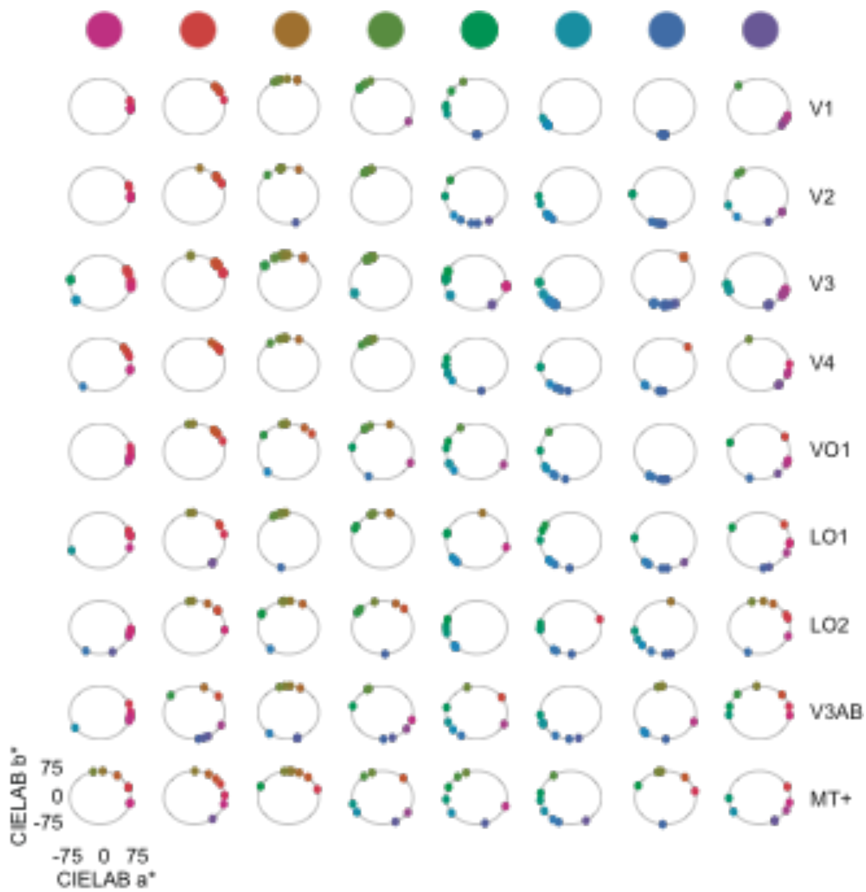
gbrouwer@cns.nyu.edu



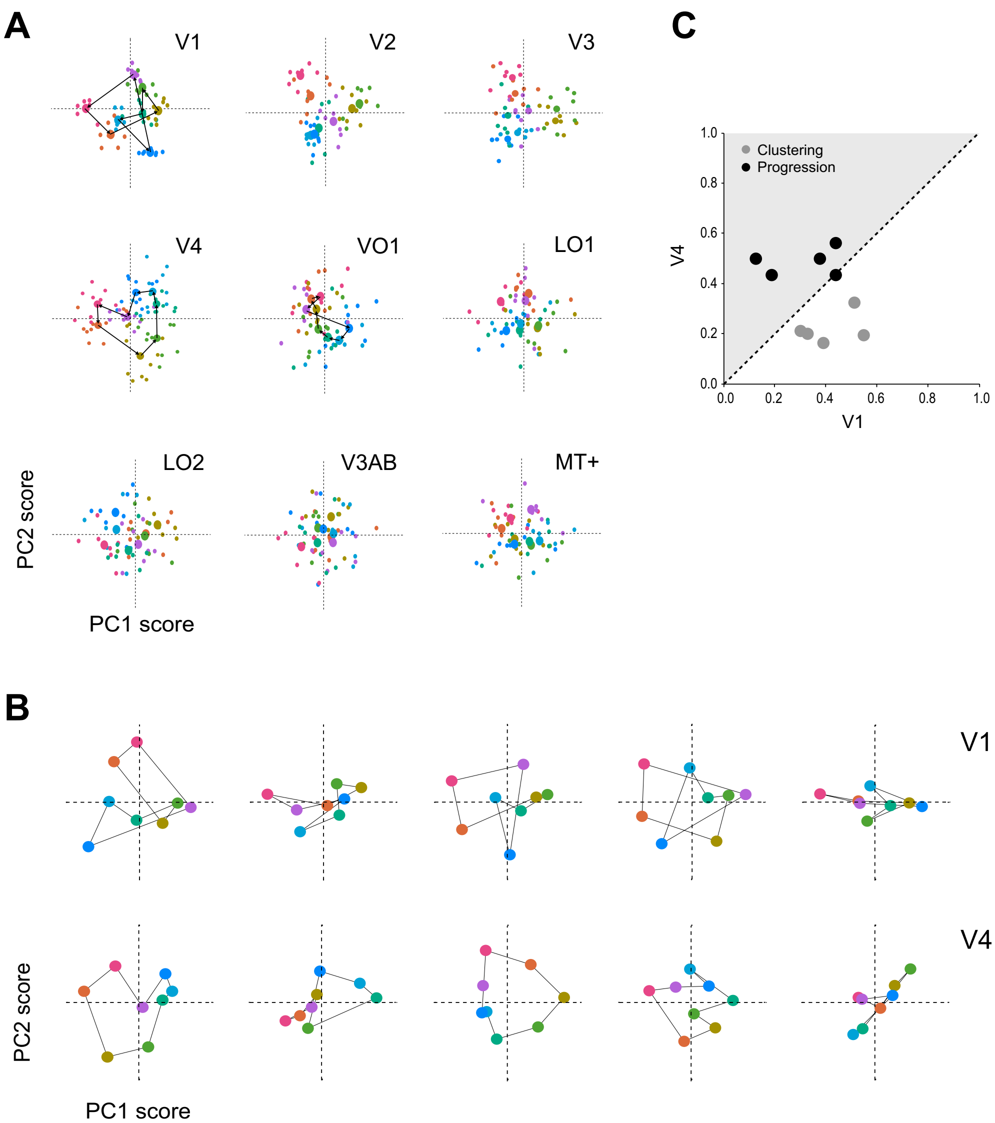
Supplementary Figure 1. Hemodynamic impulse responses. Deconvolved responses from a representative observer for visual areas V1, V2, V4 and MT+. Dark curve, mean response time course averaged over 8 runs in a single session. Shaded gray, 95% confidence intervals.



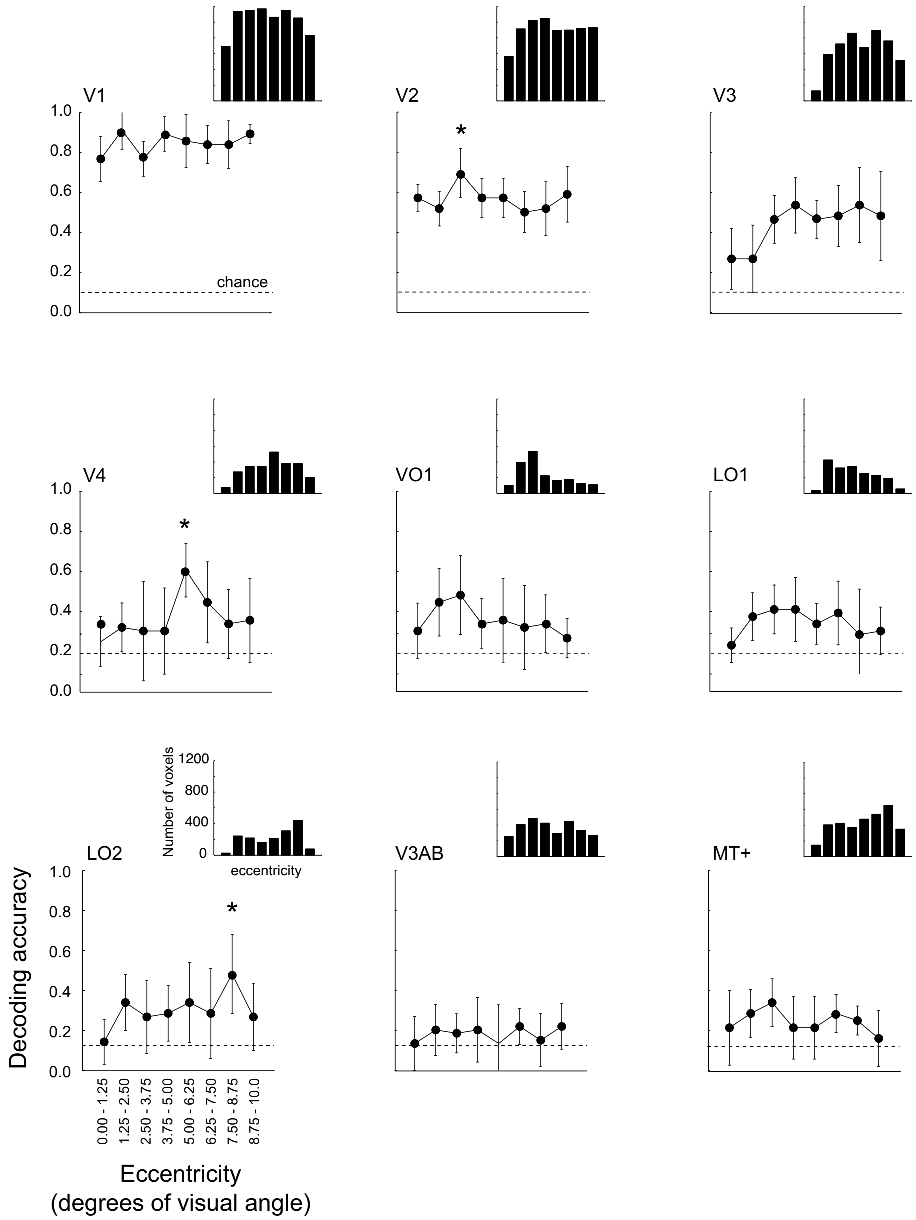
Supplementary Figure 2. Dimensionality reduction. (A) All visual areas showed a gradual increase in explained variance as more principal components were included. Each curve represents the amount of variance explained for each visual area. The number of components needed to explain 68% of the variance in the original voxel responses was similar across visual areas, reducing the number of dimensions (number of voxels after stacking all available sessions, see *Methods*) by two orders of magnitude. **(B)** After dimensionality reduction, areas with large differences in the number of voxels all reduced to a roughly equal number of components. Across visual areas, the mean number of components needed to explain 68% of the variance across visual area was 27.



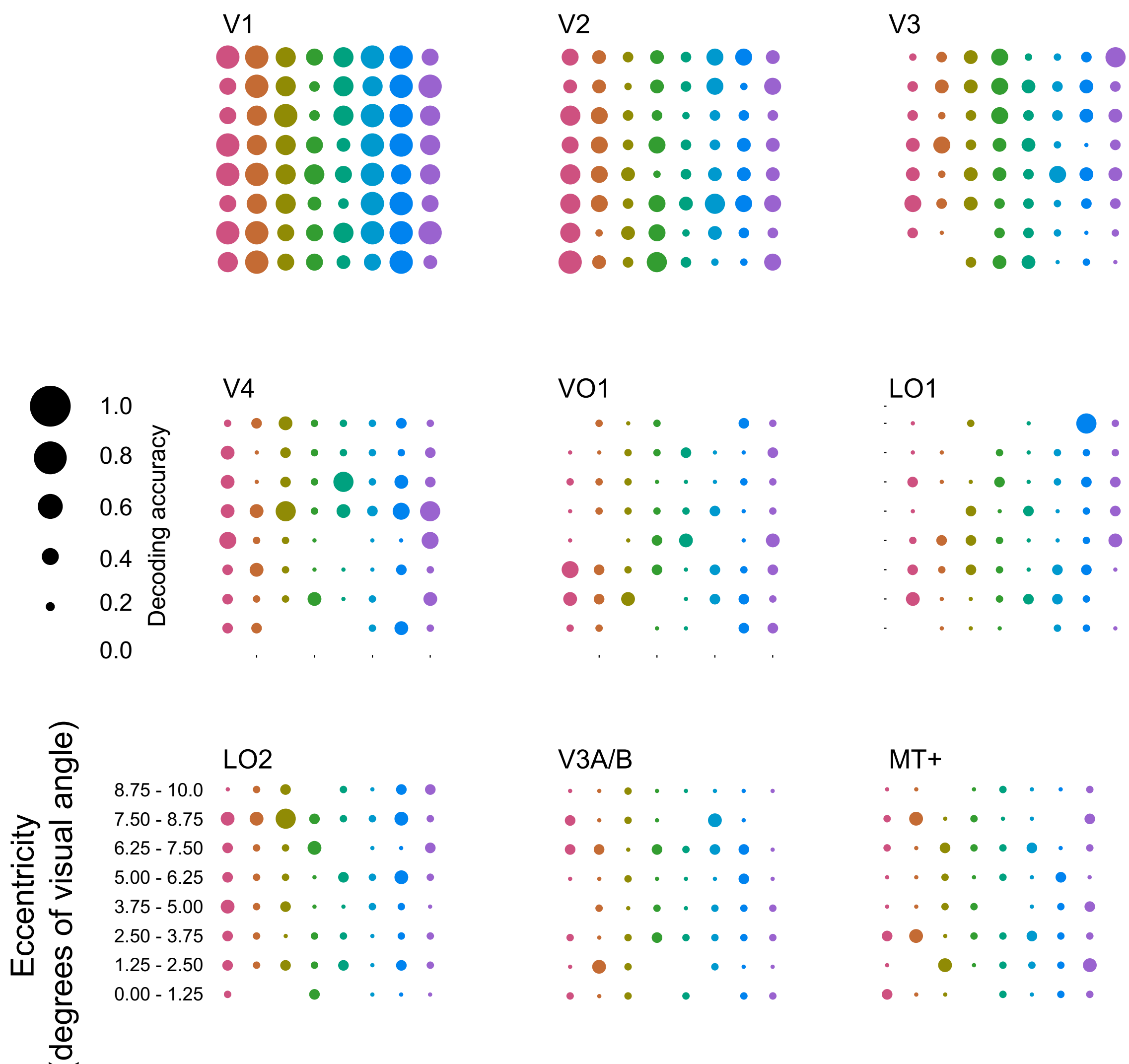
Supplementary Figure 3. Color reconstruction in all visual cortical areas. Each data point represents the color reconstructed for one run, for data combined over all sessions and observers, plotted in CIE L*a*b* space (same format as **Fig. 5A**). Each row corresponds to a different visual area. Actual stimulus color is indicated at the top of each column. Reconstruction was more accurate for early visual areas (especially in V1, V2, V3 and V4) than for higher visual cortical areas.



Supplementary Figure 4. Color spaces derived from each visual area. (A) Color spaces derived from the covariation, across voxels, in the responses to different stimulus colors, using data combined over all sessions and observers (same format as **Fig. 6A**). In V4, the first two principal components (main source of variation) reveal a nearly circular progression (not self-intersecting) through color space, with similar colors evoking the most similar responses. VO1 approaches this progression, with only a single outlier. For the remaining areas, there is no clear progression through perceptual color space. **(B)** The dissociation between areas V1 and V4 was evident for individual observers. In V1, all observers showed low progression, while in V4, progressions through color space were mostly non-intersecting, with the exception of one observer (O5, rightmost panel). **(C)** Clustering and progression for each observer, in visual areas V1 and V4. In all five observers, there was more clustering between same-color examples in V1 than V4 (gray dots), while V4 responses showed a more pronounced color space progression (black dots).



Supplementary Figure 5. Classification accuracies at different visual eccentricities. Each visual area ROI was divided into 7 different eccentricities, as defined by retinotopic mapping experiments. Decoding accuracy was computed separately for each of these 7 eccentricities. Three of the visual cortical areas exhibited significantly higher decoding accuracy at one eccentricity relative to others (V2 : $F_{7,55} = 3.28, p = 0.04$; V4 : $F_{7,55} = 2.62, p = 0.02$; LO2 : $F_{7,55} = 3.28, p = 0.04$; ANOVA). However, the eccentricities at which decoding accuracies were higher differed between these three visual areas The same analysis revealed that V3 showed a small but significant increase in decoding accuracies for larger eccentricities ($F_{7,55} = 3.28, p=0.01$). Insets show the absolute number of voxels used for decoding at each eccentricity. The significantly higher accuracies at particular eccentricities in V4 and LO2 can be attributed to the fact that there were more voxels contributing to the decoding at these eccentricities (see insets) The increase in accuracy for V3 could also have been due to an increase of the available voxels at these higher eccentricities. Overall, there was no evidence for any systematic effect of eccentricity (other than that dictated by the number of voxels) on decoding accuracies in any of the visual areas, over the range of eccentricities that we examined (between ~0.5 and 10 degrees of visual angle).



Supplementary Figure 6. **Classification accuracies for different colors at different visual eccentricities.** Similar to **Sup. Fig. 6**, we examined decoding accuracies at different eccentricities, now for each color individually. In each panel, each row represents a different eccentricity and each row one of the experimental colors. The diameter of each circle represents the decoding accuracy for a particular color. We observed no systematic effect of eccentricity on the classifier's ability to decode any individual color.