Reconstructing spatial attention in the human brain: Deep neural network activity decoded from fMRI responses to scenes predicts eye movements

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Presentation Abstract Summary Spatial attention models derived from convolutional neural networks (CNNs) provide state-of-the-art prediction of human eye movement behavior in natural images (Kümmerer, Theis, & Bethge, 2014; Kümmerer, Wallis, & Bethge, 2016). Here, we test whether features captured in CNN unit activity are sufficient to guide spatial attention in the human brain. Blood-oxygen-level-dependent (BOLD) activity evoked by natural scene images was measured (N=11) using functional Magnetic Resonance Imaging (fMRI), and fixation patterns for the same images were recorded in a separate eye tracking session. Using partial least squares regression (PLSR) and BOLD activity patterns, we decoded unit activity from the five pooling layers of a CNN trained for scene categorization (Zhou, Khosla, et al., 2016). Decoded CNN activity was averaged across filters and layers to reconstruct spatial priority maps. Reconstructed spatial priority maps from V2, V3, and hV4 predicted eye movement patterns within individuals ($p<0.005$, bonferroni corrected), and group-average spatial priority map reconstructions from V1, V2, V3, hV4, LOC, and FEF predicted eye movements ($p<0.001$) in an independent set of participants (O'Connell & Walther, 2015). Overall, we relate brain activity to eye movement behavior in natural scenes and show that features captured in CNN activity map onto representations of spatial attention priority.

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