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Top-down signals are needed for object completion in the human visual cortex

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Abstract

Objects are often partially occluded during natural viewing conditions. Therefore, visual recognition requires object completion mechanisms capable of extrapolating from partial information to infer the identity of objects. Here we combine psychophysics, theoretical modeling and neurophysiological recordings to further our understanding of the computations involved in object completion. We record neurophysiological activity from subjects with intractable epilepsy who were implanted with electrodes to localize their seizure onset focus. We recorded intracranial field potentials from areas in the temporal lobe including inferior temporal cortex and the fusiform gyrus among other areas. Subjects were presented with brief flashes (150 ms) of objects viewed through small bubbles that only partially revealed the object. Subjects performed a five-alternative forced choice categorization task. Consistent with previous psychophysical studies, recognition from partial information led to longer reaction times. At the physiological levels we observed that electrodes in visual cortex maintained their visual selectivity in response to images containing only a small fraction of object information. The responses to the partially occluded images were smaller in amplitude and showed significantly longer latencies. Furthermore, physiological responses correlated with the subjects' performance on a trial-by-trial basis. We conjecture that these longer latencies reflect indirect evidence for a requirement for enhanced processing, possibly through top-down signals, of occluded objects. Consistent with this hypothesis, we consider a purely bottom-up model of object recognition and the effect of adding top-down signals to this feedforward model. Simulating the responses of the model to the same images used in the physiology and psychophysics, we show that top-down signals improve recognition performance under occlusion conditions.

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