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Putting the Cheshire Cat Together in Amblyopia. Focus on “Spatial Resolution for Feature Binding Is Impaired in Peripheral and Amblyopic Vision”

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A perceptual “object” can be defined as a spatiotemporal coincidence of its different attributes: for example, an object could be a large, red, moving square. If the different attributes occur at different times, or in different places, they do not define an object. The world would be a strange place if it consisted of things like Lewis Carroll’s Cheshire Cat, the grin of which remained after the rest of its body had disappeared. The “binding” of different attributes or features into a coherent percept can go wrong in brief glimpses, as when we think we have seen a red Volkswagen when in reality there was a green car and a red bus (Treisman 1996). In this issue of the *Journal of Neurophysiology* (p. 142–153), Neri and Levi show that binding can be quite seriously impaired in a class of visually impairment called amblyopia (Kiorpes and McKee 1999). Amblyopes apparently find it especially difficult to bind features together even in central vision. Neri and Levi attribute this condition to a failure of co-registration between different topographic maps in the visual cortex.

The method Neri and Levi use to test feature binding is a variant on the classical “visual search” (Morgan 2003; Treisman and Gelade 1980). It is easy to find a red square (the target) against a background of green squares. Finding a red square against a background of mixed green squares and red circles is also possible, but the search takes longer. Neri and Levi measured not the time taken for the search, but the spatial scale at which it became difficult. If the whole pattern is shrunk in size, there comes a point when the search becomes very difficult, even for the simple case of red versus green. What Neri and Levi find is that in foveal vision for normal observers, the critical pattern size is the same for a “simple” search (for example, red target vs. green background) as for a “conjunction” (red square vs. green squares + red circles). This result will initially confuse readers accustomed to the classical visual search literature, where simple searches are supposed to be easier than conjunctions (Treisman 1988). The key difference is that Neri and Levi are not measuring search times but limiting spatial scale. Why search times are longer but limiting spatial scale is the same in the fovea is a problem they do not really address, but one that will have to be understood before we have a complete account of search.

A clue may be that limiting scale is the same for simple and conjunctive search in the fovea but not in the periphery. When observers looked askance at the patterns, “conjunctive” patterns had to be larger than “simple” patterns to support the same level of accuracy. (Accuracy was measured by a choice procedure, in which observers had to decide which of 2

sequentially presented patterns contained a target, i.e., an odd-man-out.) The explanation offered by Neri and Levi is that finding the target depends on co-registration of two topographic maps, one for color and one for line orientation. In peripheral vision, the registration is imperfect, leading to false conjunctions. In the fovea, on the other hand, it is sufficiently accurate not to impose a limit on performance.

The unexpected result of the study was that a sample of amblyopic observers behaved as if their fovea was like the periphery of normal observers. Amblyopia (literally, “blunt sight”) is a condition in which one or both eyes have reduced visual acuity but cannot be corrected by spectacles. The condition is usually associated with strabismus (“squint”) or alternatively, unequal focus between the two eyes, during early visual development. Various explanations have been offered, including the possibility that the primary topographic map of the retina of the affected eye in V1 is partially disordered as a result of visual deprivation (Hess and Field 1993). Neri and Levi expand this idea from V1 to prestriate cortex. They follow the standard model of cortical processing, which asserts that different features such as color and orientation are analyzed in different cortical topographic maps (Zeki 1978). Their novel suggestion is that registration between the maps is limited by position disorder, either within the maps or between them. They provide an elegant and computable model for showing how this can disorder can limit conjunctive search.

It is much too early to say whether these findings have implication for the treatment of amblyopia, at present only partially successful through patching of the affected eye. It is easy to imagine training regimes that might attempt to restore order to partially disordered topographic maps, and no doubt this will be a focus of effort in the clinical community.

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