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Topological Factors in Neon Color Spreading[1]

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1 Introduction

The human visual system is often confronted with ambiguity in its interpretation of images. Many researchers believe that the visual system can be understood, in part, by investigating the *constraints* that it uses to arrive at its perceptions. Recently researchers have begun to appreciate the power that these constraints can provide for understanding subjective contours [1] and neon color spreading [2]. In this paper we will study some of the topological factors involved in neon color spreading [3][4] using the constraint of "general position".

A typical example of the neon color spreading effect is shown in figure 1. In this display a reddish color is perceived in regions which are in fact white. Although this perception may seem inconsistent with the proximal stimulus, it may be argued that the visual system has reason to believe that the display does in fact have a reddish tint in the white area, but that its intensity is below the detection threshold. Thus, the visual system may simply be exaggerating what could, in principle, be present in the display.

We will consider the constraint of assuming that the eye of the observer and the objects in the world are in "general position" with respect to one another. This will allow us to explain why some displays produce neon color spreading while others do not.

2 Neon Color Spreading

In figure 2 we have added to figure 1 a blue ellipse at each point where a circle changes color. Each ellipse is placed on the "blue side" of the color change and intersects a circle at the point of color change. This modification has a remarkable effect on the way the display is perceived. The neon color spreading disappears. In figure 2 there is still just as much alignment of the points of color change as in figure 1. And there are still just as many points of color change, and they seem just as salient. Then why does the neon color spreading effect get weaker? In figure 3 we have added red ellipses instead of blue ones, and placed them on the "red side" of the color change. Thus, we have added *more red* to the display in regions where the red neon color spreading would be expected to occur, if it occurred. However, as in figure 2, the neon color spreading is not stronger but much weaker. Why?

An answer to this question, at the computational level, can be given using the constraint of "general position". Specifically, we believe that the human visual system assumes that

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its eye, and the objects in its environment, are independently placed relative to one another in space. Because of this assumption the visual system rejects "coincidences". It assumes that the qualitative structure of the image is stable under "small" perturbations of the position of its eye or any of the objects in the scene.

The way in which this constraint can be used to explain the perceptions we have of these figures is as follows. Let us assume, as many researchers who have studied neon color spreading have found, that figures in which neon color spreading occurs are seen by observers as containing a red transparent filter that lies above the inducing lines in the display. Now, if the neon color spreading effect occurred in figures 2 or 3, then since the color change in the circles occurs exactly where the ellipses intersect them, the eye of the observer must be looking at this scene from a very special viewpoint (assuming that there is a significant depth difference between the curves and the transparent surface). That is, if the position of the eye is chosen at random in relation to the objects in the scene, then it is highly improbable that in the image the points of intersection of the circles with the ellipses would lie on the lines defined by the edges of the transparent filter. On the other hand, if the filter and the curves are seen as being at essentially the same depth (i.e., the filter is thin and is laying directly on the curves), then it is highly improbable that the filter will have been positioned in relation to the curves so that its edges hit the points of intersection of the circles with the ellipses. The same sort of argument applies if we think of the redness as being due to a "redish mist" that surrounds the curves in space, rather than a transparent surface.

In figure 4 we have added red and blue ellipses to figure 1 at "random" positions on the circles. Note that the neon color spreading effect is enhanced here, as might be expected.

Of more than 10 naive color normal subjects to whom we have shown these figures, all have reported seeing a reddish tint in the square central region in figures 1 and 4, and little or none in figures 2 and 3. Thus it seems that the neural mechanism which is responsible for neon color spreading takes account of the general position constraint.

References

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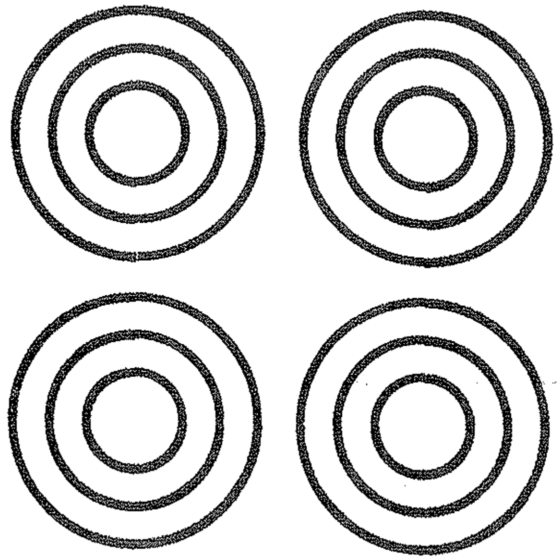

Figure 1

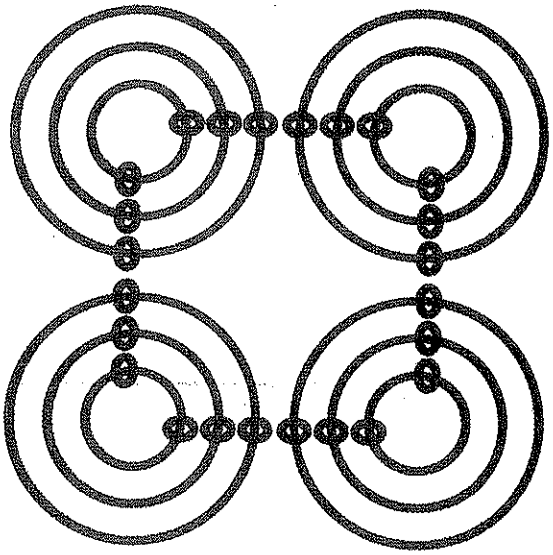

Figure 2

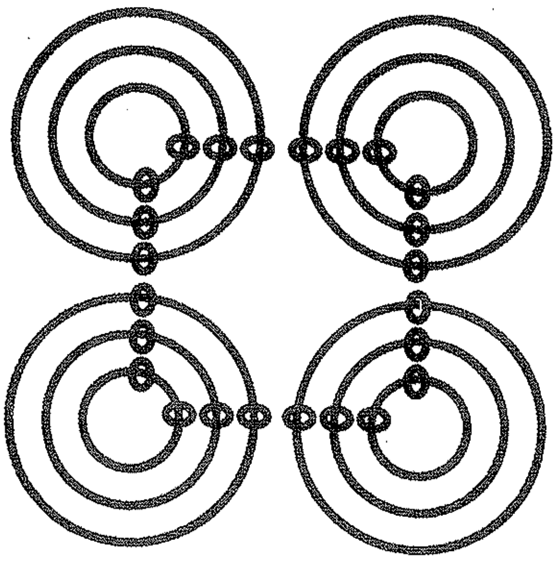

Figure 3

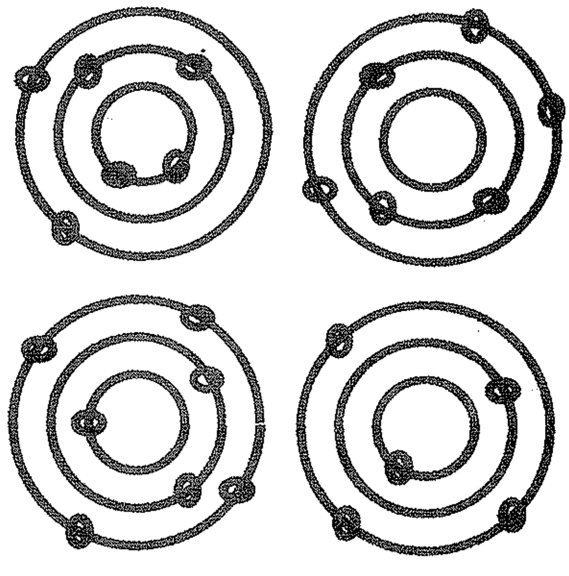

Figure 4