Abstract. Radial lines of Ehrenstein patterns induce illusory scintillating lustre in gray disks inserted into the central gaps (scintillating-lustre effect). We report a novel variant of this illusion by replacing the radial lines with white and black radial fins. Both white and gray disks inserted into the central gaps were perceived as scintillating, if the ratio of the black/white fin width were balanced (ie, close to 1.0). Thus, the grayness of the central disk is not a prerequisite for the scintillation. However, the scintillation was drastically reduced when the ratio was imbalanced. Furthermore, the optimal ratio depended on the color of the center disks.

Keywords: visual illusion, scintillation, scintillating-lustre effect, luminance contrast, Ehrenstein pattern.

The Ehrenstein figure etches an illusory contour of brightness-enhanced region at the central gap surrounded by radial lines (Ehrenstein 1941). Pinna et al (2002) modified the Ehrenstein pattern by inserting gray disks into the central gaps and found that the gray disks are perceived as pulsating or scintillating (scintillating-lustre effect; Pinna et al 2002, Figure 1b). However, they also reported that the scintillation was not perceived with the original white gaps. We extend further Pinna’s scintillating-lustre effect and report a novel variant of the illusory scintillation. The central white disks (we refer to the central gap as a “disk”), as well as the gray disks, appear to be scintillating when the radial lines of Ehrenstein figure are replaced with white and black fins (Figure 1). In addition, the scintillating becomes more conspicuous when the ratio of the black/white fin-width was balanced.

To quantify our observations, six naive observers (four males and two females, 21–34 years old) rated the strength of illusory scintillation of the white and gray central disks. The visual stimuli were Ehrenstein-like patterns with white or gray center disks (Figure 1). Instead of radial lines, 24 white and 24 black fins were placed alternately. The ratio of black/white fin-width varied from 0.2 to 1.8, and the size of the central disk also varied from 10% to 40% of the radius of the Ehrenstein-like patterns. The stimulus display consisted of 8 × 5 arrays of identical Ehrenstein-like patterns. Observers viewed the stimulus freely without any time constraints and rated the strength of scintillation by 7-point scaling. Prior to the experiment, observers were familiarized with illusory scintillation. Also, observers were shown a reference stimulus (gray disk with ratio = 1.0 and size = 20%) and told that this was associated with a value of “5” on the rating scale. They were also shown gray disks without radial fins and told that this was associated with a value of “1” on the rating scale (the lower limit).

Both white and gray disks were perceived to be scintillating. The strength of illusory scintillation showed strong dependencies on the ratio of black/white fin-width, but the
Figure 1. (a, b) Examples of visual stimuli of a stronger illusory effect (a: ratio = 0.8, size = 10%; b: ratio = 1.4, size = 20%). The radius of each Ehrenstein pattern was 2.8°. The luminance was 0.005 (black), 12.16 (gray), and 88.07 (white) cd/m². (c) Mean rating score of illusory scintillation as a function of ratio of white to black fin width (left, size was fixed to 20%) and disk size (right, ratio was fixed to 1.0). The gray and black colors indicate gray and white central disks, respectively. The error bars indicate the standard errors of means. The circles in the figure indicate the rating score of the reference stimulus.

A two-way repeated-measures ANOVA revealed a significant interaction between color and ratio, $F(8, 40) = 34.3, p < .001$. In general, the imbalances in black/white fin-width drastically weakened the scintillation of both white and gray disks (the effect of ratio: white: $F(8, 40) = 17.1, p < .001$; gray: $F(8, 40) = 89.9, p < .001$). In addition, the gray disks appeared to be more scintillating with the blackish radial fins (peak ratio 1.4), while the white disks appeared to be more scintillating with the whitish radial fins (peak ratio 0.8). We also found that the larger central disks degraded the illusory scintillation, $F(3, 15) = 7.98, p < .05$, irrespective of the
disk color (Figure 1c, right), which was consistent with the original scintillating-lustre effect (Pinna et al 2002, figure 6).

The illusory scintillation induced by the radial fins may be partially related to the scintillating grids such as the Herman illusion (Schiller and Carvey 2005), Bergen illusion (Bergen 1985), and scintillating grid illusion (Schrauf et al 1997). However, since we never see illusory black dots inside the central disks, and since the straightness of the grid lines is crucial for those grid-type scintillations (Geier et al 2008), the underlying mechanisms of scintillation with radial fins and those with straight grids might be different. Currently, we do not have a concrete idea for the underlying mechanisms, but they might include several processes such as simultaneous contrast, motion blur induced by eye or stimulus motion, and illusory motion induced by microsaccades (eg, the Enigma illusion; Kumar and Glaser 2006; Troncoso et al 2008).

The imbalanced ratio of black/white fin width drastically reduced the illusory scintillation (Figure 1c, left). This was the case in the “radial lines” of the Ehrenstein patterns (Pinna et al 2002, 2004), and hence the scintillation of the central white disks might have gone unnoticed in previous studies. Why does the ratio modulate the strength of illusory scintillation, and why does the selectivity of the ratio depend on the color of the central disks? At the moment, we conjecture that the (mean-luminance) contrast between the radial and central region would be one determinant of the strength of illusory scintillation.

The present illusion shows that the scintillation in the Ehrenstein-like patterns depends on the property of radial patterns. The effects of other geometric properties of radial patterns, such as number, shape, and length, should be examined further. Another intriguing issue is the difference between the luminance and color contrast of the fins. Our observations suggest that green–red radial fins can also induce scintillation, but this effect may be due to a slight luminance contrast rather than color contrast. All these issues will provide further support for understanding the perceptual organization of Ehrenstein-like patterns.

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