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Last but not least

A new motion illusion: The Rotating-Tilted-Lines illusion

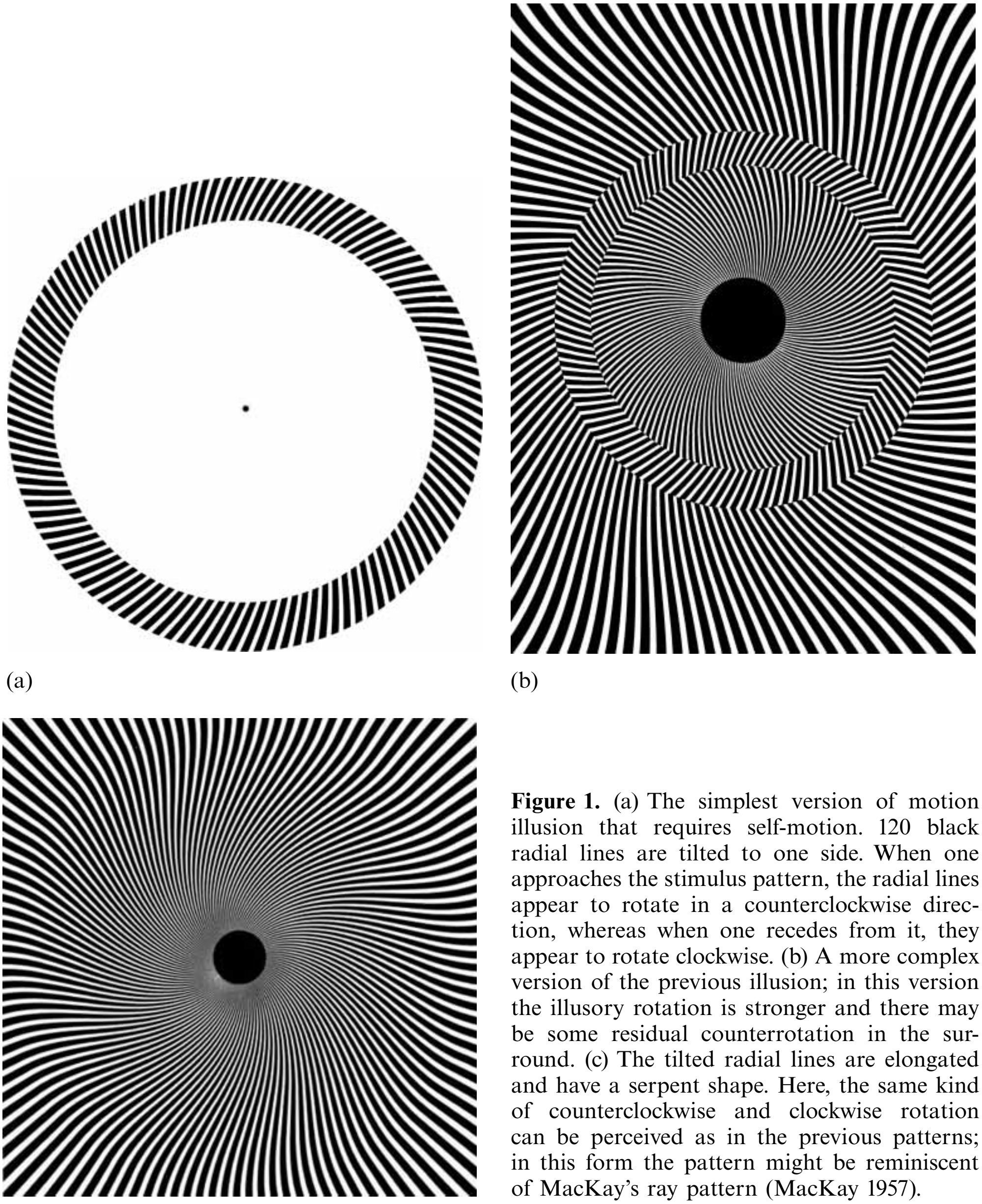
Introduction

Visual illusions are not just entertaining—they also are non-invasive means for investigating human brain mechanisms. While they show us where our visual system fails, they can also tell us how it works. Therefore, we introduce here a new motion illusion that could represent the simplest pattern that elicits illusory motion through self-motion. It may be instrumental for future research to better understand motion processing in the brain.

Figure 1 represents the new Rotating-Tilted-Lines illusion. In its simplest form (figure 1a) this new illusion arises in a circular pattern of 120 black, radial lines tilted 45° to the right and presented on a white background (ECVP 2005 Best Visual Illusion Contest; presented in Martinez-Conde et al 2005). When one approaches the stimulus pattern, the radial lines appear to rotate in the counterclockwise direction, whereas when one recedes from it, they appear to rotate clockwise. If the lines are tilted to the left, the illusory effects occur in the opposite direction as a function of the self-motion. The length of the lines is not critical in this illusion. Only if the lines are too short for their tilt to be perceived, the illusion disappears. These observations suggest that the tilt of the lines is the most important factor—the illusory effect disappears if the lines are arranged radially—as direction-selective neurons need to be taken into account for the illusory rotation (Gurnsey et al 2002; Morgan 2002). We also created a more complex version of this illusion. The 'ring' of tilted lines is now embedded in a context of an equal number of lines oriented in the opposite direction representing the background (figure 1b). Here, the illusory rotation is stronger and there may occur some residual counterrotation in the surround. Finally, in figure 1c the tilted radial lines of figure 1a are elongated, having only a serpent shape (as the surround in figure 1b) without a ring of lines (this pattern is somewhat similar to MacKay's ray figure). Again, while approaching and receding from the pattern, counterclockwise and clockwise rotation is perceived depending on the direction of self-motion and the orientation of the lines. But the rotation perceived is completely different from the 'complementary afterimage' described by MacKay (1957). His subjects reported spontaneous illusory rotation that could be in the clockwise or counterclockwise direction. In contrast, the direction of perceived motion in our illusion is a function of the direction of the subject's self-motion. This new kind of illusion also works perfectly well if the stimulus is moved instead of the observer's body. Informal observations on forty subjects (age range 19 – 70 years) revealed that everybody was able to perceive the phenomena described above while moving towards or away from these patterns.

Combining two motion illusions

An additional aim was to create a new pattern that could elicit two different kinds of illusory motion: a spontaneous one and one due to self-motion. In figure 2 the two designated illusory effects are combined. The tilted line pattern of figure 1a is superimposed onto the coloured rings of the Enigma figure created by Isia Leviant in 1981 (Leviant 1996). The effect of perceived clockwise and counterclockwise rotation is still present on approaching the pattern and receding from it (or moving the pattern towards or away from the eyes). In the first case, the direction of motion is opposite to the inclination of the lines (backward); in the second, it is forward. Viewed statically, streaming motion on the coloured rings appears as it does in the Enigma illusion.



(a) (b) (c)

Figure 1. (a) The simplest version of motion illusion that requires self-motion. 120 black radial lines are tilted to one side. When one approaches the stimulus pattern, the radial lines appear to rotate in a counterclockwise direction, whereas when one recedes from it, they appear to rotate clockwise. (b) A more complex version of the previous illusion; in this version the illusory rotation is stronger and there may be some residual counterrotation in the surround. (c) The tilted radial lines are elongated and have a serpent shape. Here, the same kind of counterclockwise and clockwise rotation can be perceived as in the previous patterns; in this form the pattern might be reminiscent of MacKay's ray pattern (MacKay 1957).

There, the observer perceives a streaming or spinning motion on the coloured rings in one or the other direction, whereas the direction of perceived motion changes frequently (Gori et al 2005). This streaming motion in Enigma is still present (although slightly weaker) when the ciliar muscles of the eye are paralysed (Zeki 1994; Mon-Williams and Wann 1996; Hamburger and Spillmann 2005) or in a long-lasting stabilised afterimage (Hamburger and Spillmann 2005). Which of the two combined illusory effects is perceived in figure 2 depends on the mode of presentation, ie constant vs variable observation distance. As a side note, with static presentation of the stimulus pattern, one may additionally perceive a shimmer or jitter of the tilted radial lines as reported by MacKay (1957, 1958) and Gregory (1993, 1995, 2002a, 2002b).

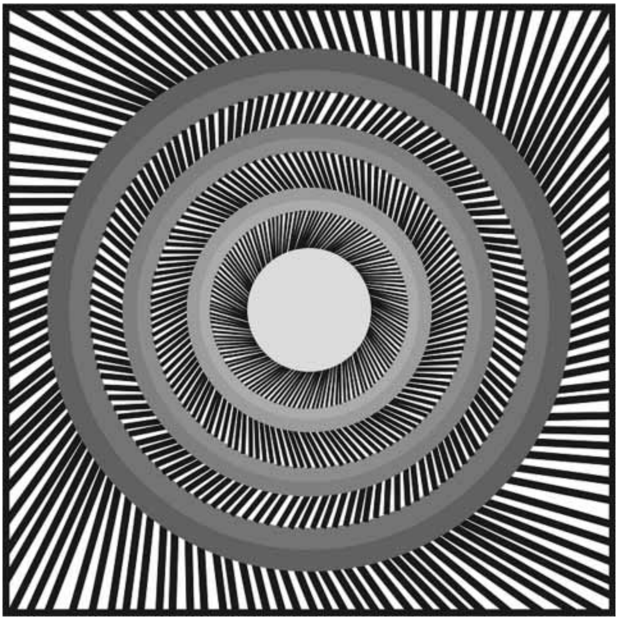


Figure 2. The illusory motions of the Rotated-Tilted-Lines illusion and the Enigma illusion become united in a single pattern. Approaching and receding from the pattern leads to rotation of the tilted radial lines in clockwise or counter-clockwise direction, while fixating the centre of the static patterns leads to spinning motion on the three coloured rings. A colour version of this figure can be viewed on the *Perception* website: http://www.perceptionweb.com/misc/p5531/.

In contrast to the streaming motion in Enigma, this effect does not occur with paralysed ciliar muscles (Mon-Williams and Wann 1996; Hamburger and Spillmann 2005) or in a long-lasting stabilised afterimage (Gregory 2002a; Hamburger and Spillmann 2005). These results suggest cortical mechanisms for the Enigma illusion but a more low-level processing of the jitter in MacKay's ray figure.

Discussion and conclusion

(i) The new Rotating-Tilted-Lines illusion presented in the first part (figures 1a – 1c) appears to be the basic pattern or, at least, the simplest figure known so far that elicits illusory rotary motion caused by self-motion. Similar, but more complex phenomena have been reported by Pinna and Brelstaff (2000) and later on by Kitaoka (2000, 2001) in several forms. However, their inducing patterns are different from ours as they use micropatterns (tiles) with dark and bright edges (or stimulus elements) that are subject to the aperture effect. In their cases, the polarity of stimulus elements (alternating black and white elements of a certain orientation; high luminance contrast) seemed to be the important parameter for the occurrence of the illusions. Gurnsey et al (2002), using complex Gabor patches, found that it is not the precise geometrical structure of the micropatterns that is critical, but the low-frequency orientation structure in the display. The luminance relationship of the static elements seems to be the main factor also eliciting illusory motion in the Rotating Snakes by Kitaoka (2000). Physiological evidence for the importance of luminance contrast was presented by Conway et al (2005) who studied direction-selective neurons in the visual cortex of macaque during observation of the Rotating Snakes. In comparison, the illusory rotation of the pattern presented here is obtained by simple tilting of the black lines that compose the ring. No micropatterns are used here. Moreover, the illusory motion is present even at lower luminance contrasts. This last finding challenges the idea that the luminance relationship of the elements could be a good explanation for our new illusion. We suggest that the illusory motion derives from a difference in motion vector based on the sequential change of orientation of the lines. The enhanced rotation observed in the complex version of our pattern may additionally arise from the difference in phase and orientation of the abutting lines. As a side note, another way to enhance the illusory effect is to present a smaller circle of lines tilted in the other direction inside figure 1a. Then we obtain the same effect as in the Pinna – Brestaff illusion without using micro-patterns.

We are planning to investigate the hypothesis described above by systematically varying the angle at which the grating lines abut each other. We suggest that our simplest version of the illusion could be a candidate for single-cell recording studies, exploring how direction-selective neurons are involved in this 'failure' of our brain to interpret the reality. Moreover, future brain-imaging studies could benefit from this new illusion endorsing recent fMRI studies of the Pinna – Brelstaff illusion (Budnik et al 2005) and the Spinning-Disk illusion (Williams et al 2005) and establish whether real motion and illusory motion are both processed within the same brain areas. Use of our simpler forms of the rotary-motion illusion allows better experimental control and could reduce the number of possible artifacts (noise) in investigating processing mechanisms of illusory motion in the brain because of its simplicity.

(ii) With the combination of illusions (figure 2), we demonstrate that a single pattern can elicit two different kinds of rotary motion. Combining two different illusory effects may not be a novel finding, but here the mode of presentation is crucial for the different effects to occur. Static presentation gives rise to the Enigma illusion, whereas with dynamic presentation an illusory counterrotation of the lines is perceived. Each may require different mechanisms of processing in the visual system and different explanations. This pattern shows us that we need to distinguish different 'classes' of motion illusions — by mode of presentation and maybe by processing mechanisms in the visual system and cortex as well — instead of subsuming them all under the simple term of 'motion illusion'.

(iii) Last but not least, we would like to stimulate researchers' and naive observers' thoughts with our new illusions.

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