A BRIEF CLASSIFICATION OF COLOUR ILLUSIONS

Akiyoshi Kitaoka[1]
[1]Department of Psychology, Ritsumeikan University

ABSTRACT

Here I try to classify some colour illusions that have been known so far. They include colour constancy, colour illusion of assimilation and contrast, visual completion, visual scission, and colour induction by motion.

Keywords: colour illusion, colour constancy, assimilation, contrast, visual completion, visual scission. motion

CONTACT

Email akitaoka@lt.ritsumei.ac.jp

INTRODUCTION

There are a cumulative number of visual illusions in shape, motion, brightness, or colour. Although shape illusion (geometrical illusion) has been well documented and classified in many literatures[1,2], classification of colour illusion seems to be something complex. Here I select some hue illusions and try to classify them.

COLOUR ILLUSION BY COLOUR CONSTANCY

Colour constancy refers to a phenomenon that observers can see the "true" colour of an object to some extent even if illumination is changed in colour. I regard colour constancy as a kind of colour illusion, because colour constancy can be depicted, as shown in fig 1. Colour constancy quite resembles colour contrast, because the opponent colour is induced in the target area by the surrounding colour. However, the effect of colour contrast is much weaker than that of colour constancy (fig 2).

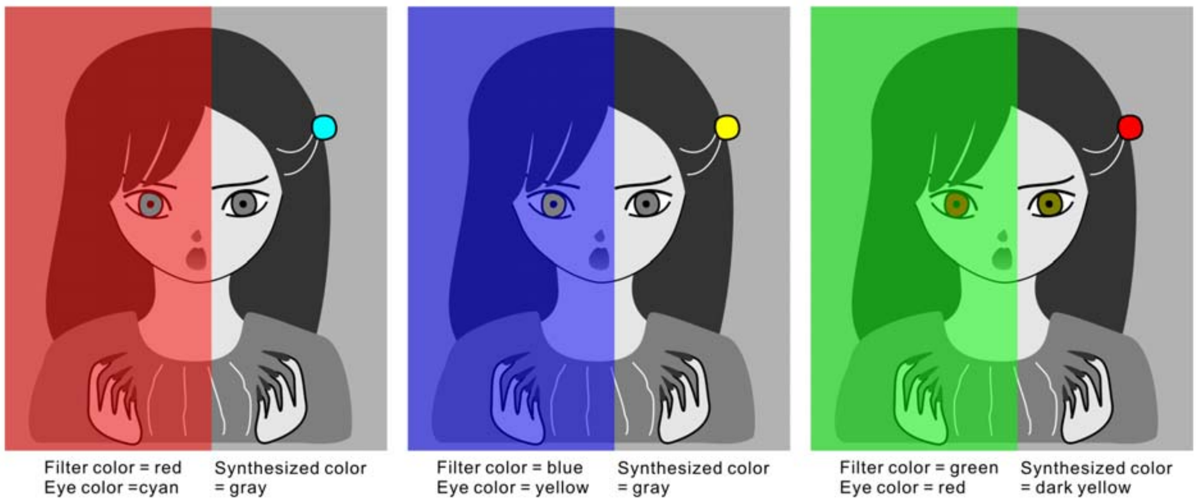

Fig 1. Colour illusion by colour constancy. The right eye appears to be cyan in the left image, yellow in the middle one, and red in the right one, though in each image the right eye is the same colour as the left eye. Colour constancy is supposed to be perfect when in each image the right eye appears to be the same colour as the bead on the hair.

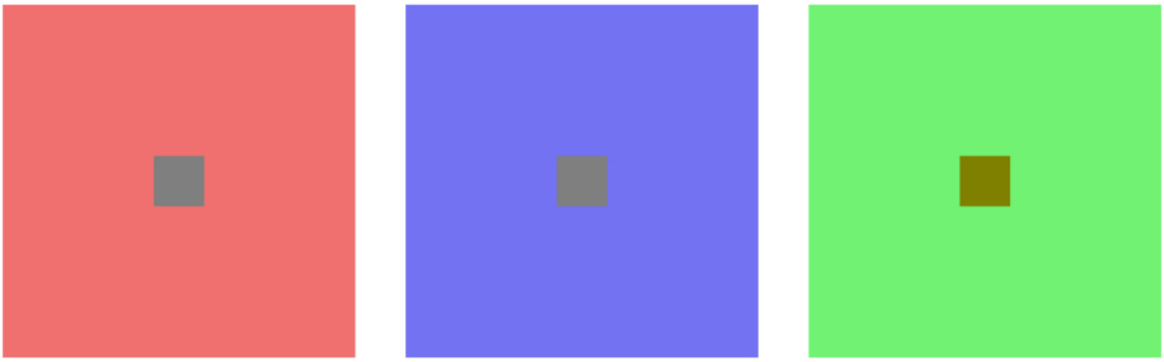

Fig 2. Colour contrast using the same colour combinations as fig 1. The small square in each image is the same colour as the "eye" in fig 1, respectively. The surround in each image is the same colour as the "skin" in fig 1, respectively. However, the colour induction is not so strong as fig 1.

COLOUR ILLUSION BY ASSIMILATION AND CONTRAST

When an area are enclosed by a coloured surround and both are partly occluded by a coloured grating, the area appears to be tinted in the same direction as the colour of the grating (assimilation) as well as in the direction opposite to the colour of the surround (contrast)[3,4]. This effect is called the Munker illusion (fig 3a). A similar effect is obtained if the occluder is replaced by a coloured grid (chromatic dungeon illusion: fig 3b), repetitive coloured dots (dotted colour illusion: fig. 3c), or a coloured checker pattern (De Valois-De Valois illusion[5]: fig 3d). The chromatic dungeon illusion is the colour version of Bressan's dungeon illusion[6]. The dotted colour illusion is the colour version of White's dotted brightness illusion[7].

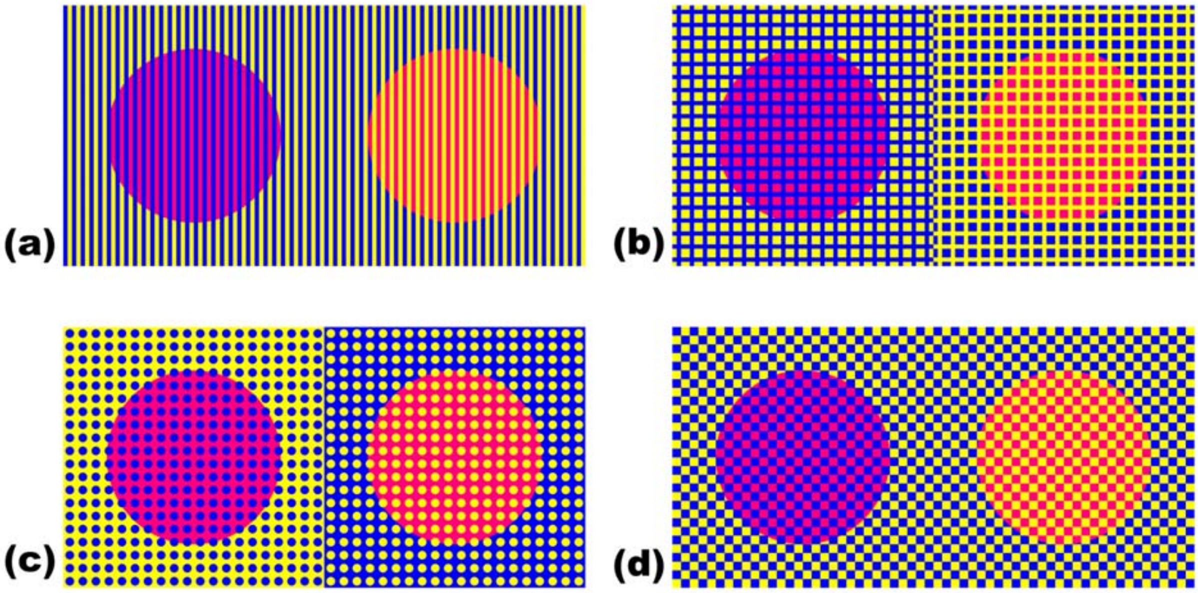

Fig 3. Colour illusion by assimilation and contrast. In each panel, the left circle appears to be magenta while the right one appears to be orange, though they are the same colour. (a) Munker illusion, (b) chromatic dungeon illusion, (c) dotted colour illusion, (d) De Valois-De Valois illusion.

In these illusions, the contribution of colour contrast appears to be weaker than that of colour assimilation if they are examined separately (fig 4). However, there is evidence that colour contrast plays an important role in this group of colour illusions. For example, fig 5 shows illusory yellow in the left circle in each image though it is the same white as the right circle. To explain this effect, colour contrast should be taken into account, as follows.

In the left half of figs 5a or 5c, colour contrast induces red as the opponent colour of cyan, while colour assimilation gives green; then the induced red and green are mixed to produce yellow. In the left half of figs 5b or 5d, colour contrast induces green as the opponent colour of magenta, while colour assimilation gives red; then the induced green and red are mixed to produce yellow.

On the other hand, illusory blue is induced in the right circle of each image. The effect is actually manifest when the induced area is black (fig 6). Moreover, when the induced area is grey, the induced colour seems to be the mixture of colour contrast and colour assimilation, with the former being more effective than the latter (fig 7).

In sum, not only colour assimilation but also colour contrast plays an important role in this group of colour illusions.

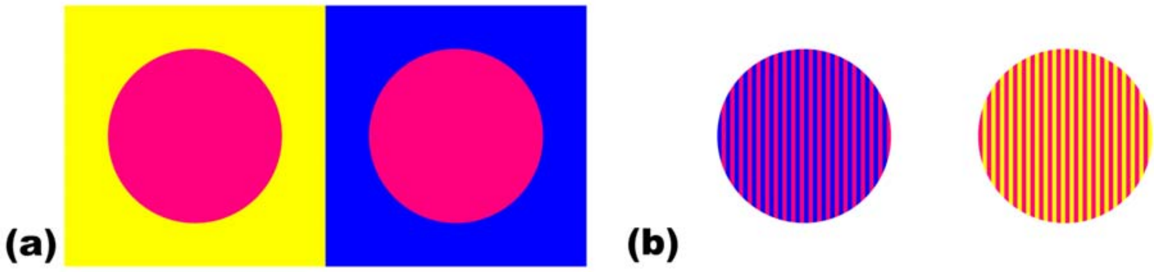

Fig 4. Separately demonstrated colour effects involved in the Munker illusion (fig 3a). (a) Colour contrast shows a relatively weak effect. (b) Colour assimilation renders a relatively strong effect.

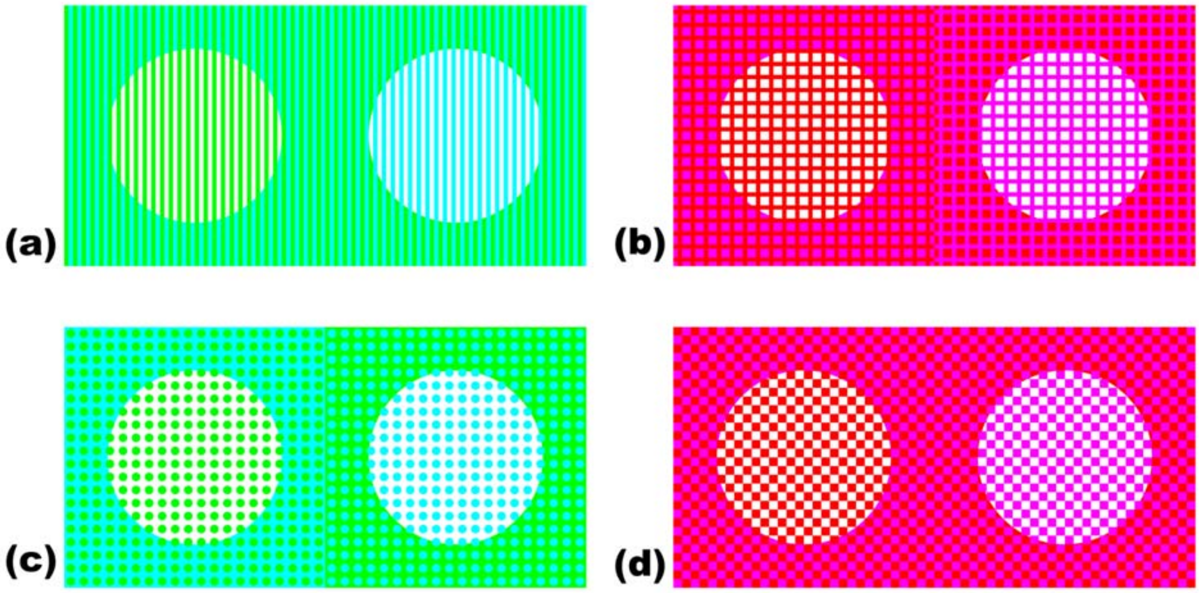

Fig 5. Yellow induction. In each image, the left circle is physically the same white as the right one, but the former appears to be yellowish. This effect can be explained with colour mixture between the colour induced by contrast and the one induced by assimilation. (a) Munker illusion, (b) chromatic dungeon illusion, (c) dotted colour illusion, (d) De Valois-De Valois illusion.

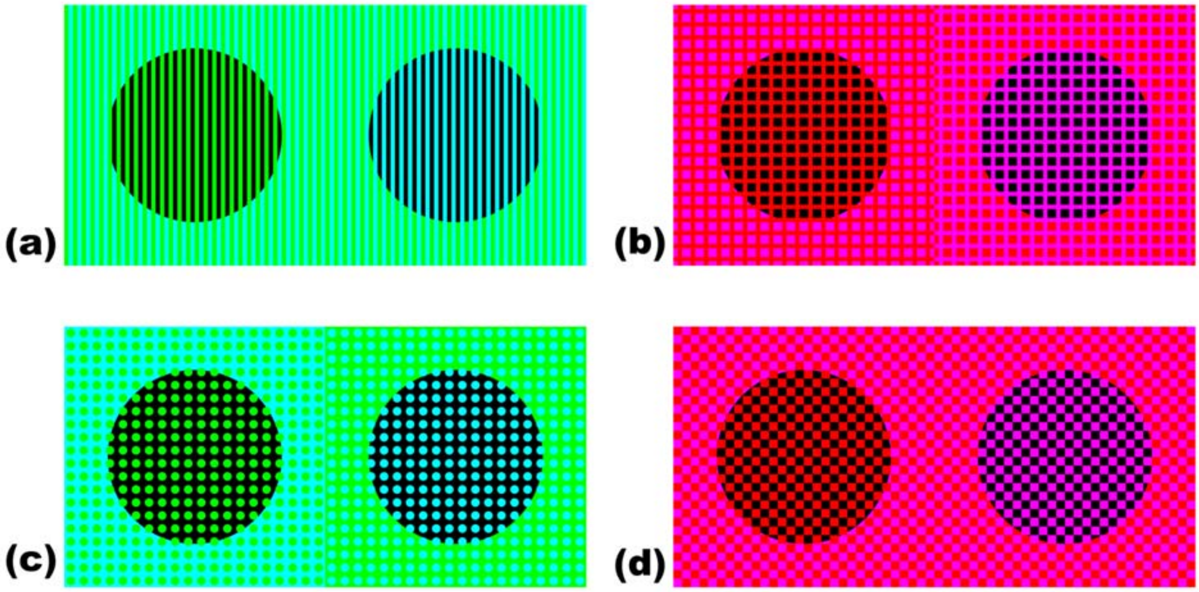

Fig 6. Blue induction. In each image, the right circle is physically the same black as the left one, but the former appears to be bluish. (a) Munker illusion, (b) chromatic dungeon illusion, (c) dotted colour illusion, (d) De Valois-De Valois illusion.

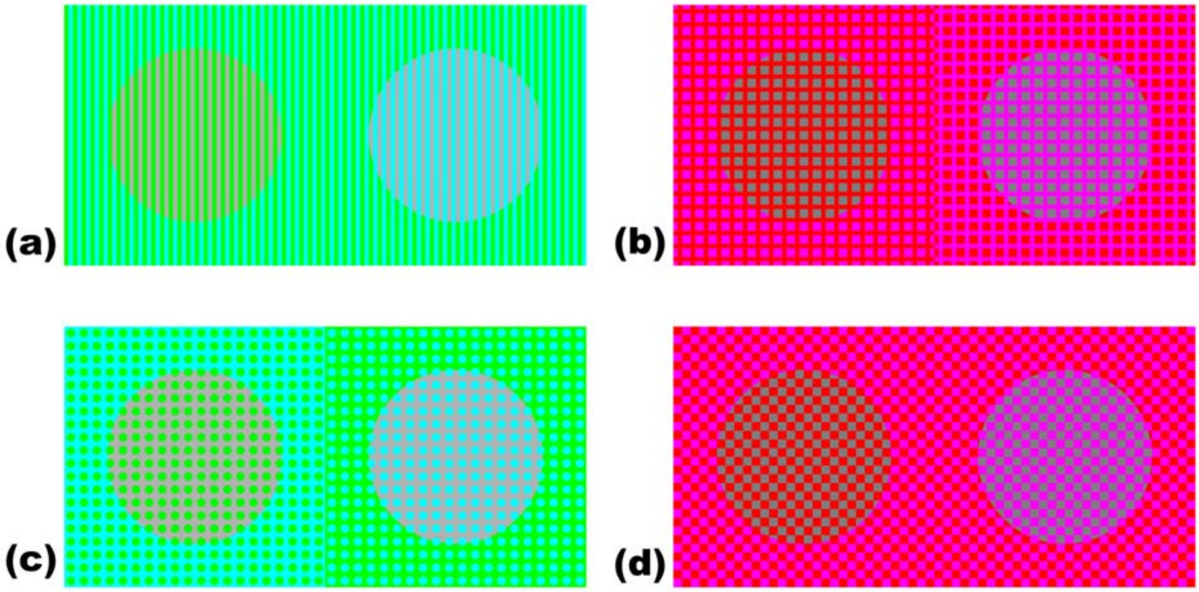

Fig 7. A condition showing slight superiority of colour contrast to colour assimilation. This effect is manifest when images are displayed on PC displays. (a) and (c) Yellowish-red is induced in the left circle while bluish-magenta is shown in the right. (b) and (d) Yellowish-green is induced in the left circle while bluish-cyan is shown in the right. In each image, however, the left circle is physically the same grey as the right one. (a) Munker illusion, (b) chromatic dungeon illusion, (c) dotted colour illusion, (d) De Valois-De Valois illusion.

COLOUR ILLUSION BY VISUAL COMPLETION

Colour filling-in phenomena are observed in several configurations, *e.g.* neon colour spreading[8,9,10,11] (figs 8a-c), Pinna's watercolour illusion[12] (fig 8d), Sohmiya illusion[13] (fig 8e), or the chromatic Craik-O'Brien-Cornsweet effect (fig 8f). These illusions are characterized not only by colour assimilation coming from the coloured inset but also by colour contrast coming from the surround[9,11,13].

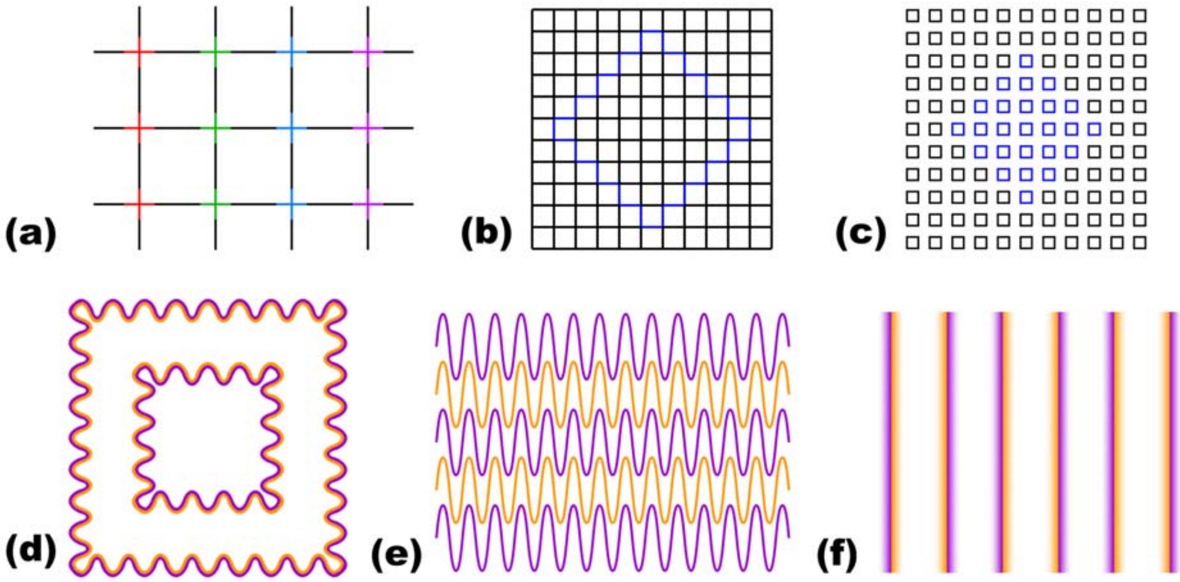

Fig 8. Colour illusion by visual completion (colour filling-in phenomena). (a), (b), (c) neon colour spreading. (a) Transparent circular or diamond-like patches of the same colour as crosses are observed over the crosses. (b) A bluish contour of diamond shape is observed over the blue staircases. (c) A bluish diamond is observed over the blue squares that form a diamond shape. (d) Watercolour illusion. The corridor area appears to be coloured yellowish orange, though it is actually white. (d) Sohmiya illusion (wave-line colour illusion). The white background of the second and fourth rows of waves appears to be coloured yellowish orange. (e) Chromatic Craik-O'Brien-Cornsweet effect. The white areas flanked by orange borders appear to be coloured yellowish orange.

VISUAL SCISSION

Visual scission or figure-ground segregation also produces colour illusion. Fig 9 shows the chromatic version of the Anderson illusion[14], in which the inset appears to be either a yellow disk or a blue one depending on the surround.

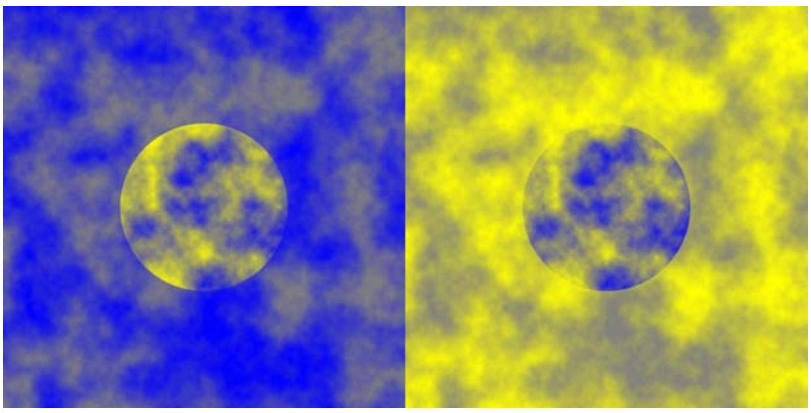

Fig 9. Colour illusion by visual scission (chromatic version of the Anderson illusion). The left disk appears to be yellow while the right one appears to be blue, though both are physically identical in colour and texture.

COLOUR ILLUSION BY MOTION

Motion produces colour in some situations such as Benham's top. Here I demonstrate a novel colour illusion induced by motion. Fig 10 shows colour increment when observers fix their eyes on the center and approach or leave the image. The inner ring appears to get more reddish during observers are approaching, while the outer one appears to get more reddish during they are leaving. My speculation is that this phenomenon might depend on different latencies of colour perception that a longer-wavelength colour is perceived faster than a shorter-wavelength colour (fig 11).

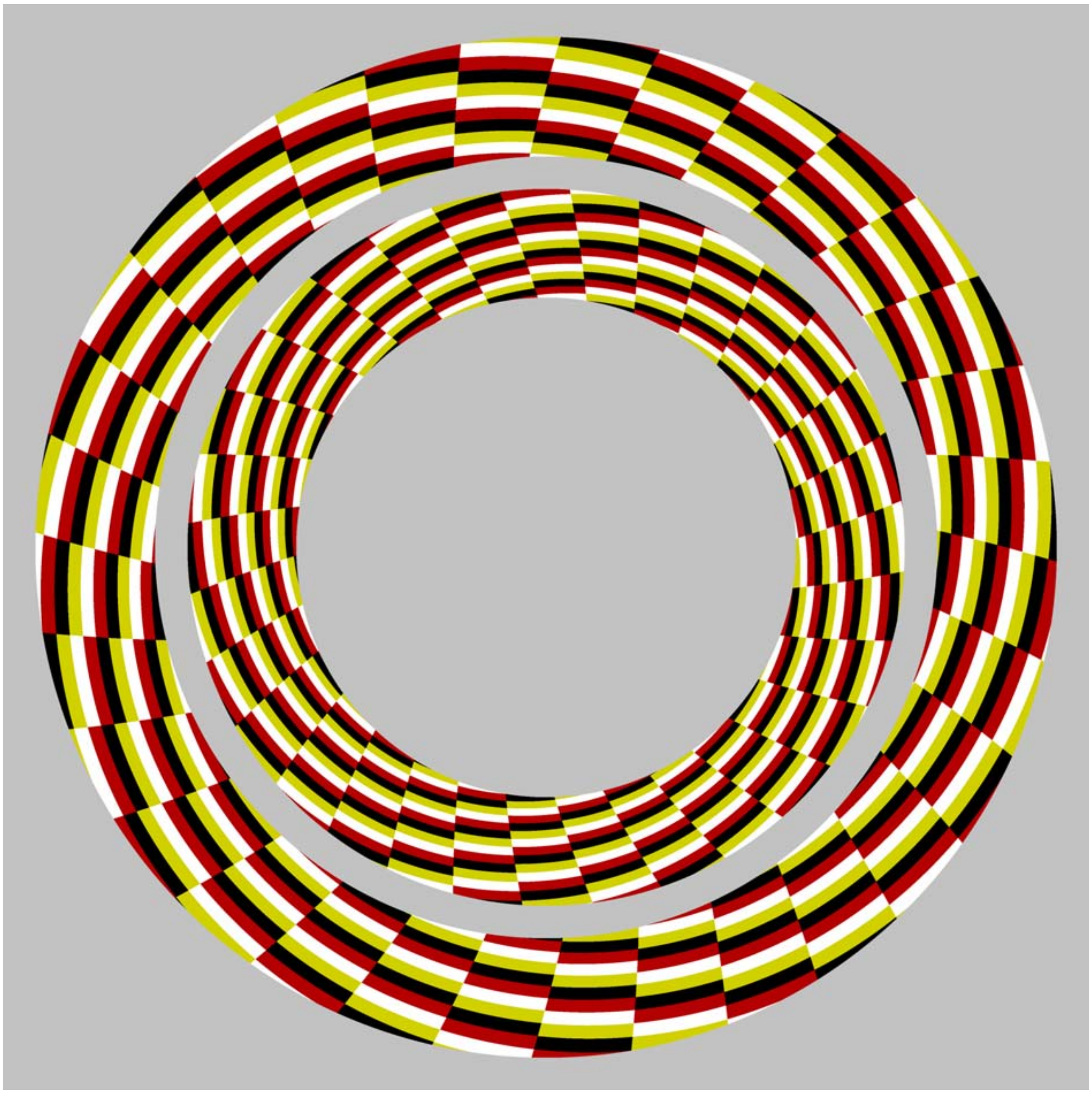

Fig 10. Colour illusion by motion. The inner ring appears to get more reddish during observers approach the image fixing their eyes on the center, while the outer one appears to get more reddish during they leave the image. In addition, there are two anomalous motion illusions. One is that the inner ring appears to contract automatically while the outer one appears to expand. The other is that the inner ring appears to rotate counterclockwise during observers approach the image fixing their eyes on the center, while it appears to rotate clockwise during they leave the image. These two motion illusions do not necessarily depend on colour.

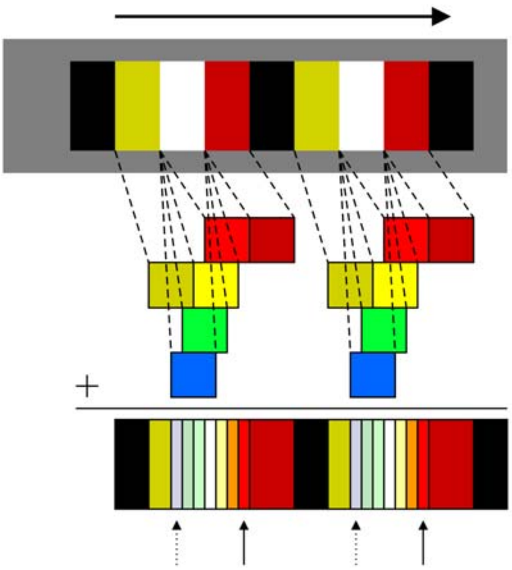

Fig 11. Different latency hypothesis that explains the motion-induced red increment. It is hypothesized that a longer-wavelength colour is perceived faster than a shorter-wavelength colour. When a repetitive pattern of black, yellow, white, red, and black is moved in this direction, (1) the front edge of the red strip simply goes in the black area, (2) the front edge of a white strip emits a red margin ahead (solid arrow), and (3) the rear edge of the white strip leaves a blue margin behind and this blue part cancels colour with the following yellow (dotted arrow). In total, this process of colour separation or cancellation gives the apparent increment of red.

CONCLUSION

Here I classified colour illusions into several categories: colour constancy, colour illusion of assimilation and contrast, visual completion, visual scission, and colour induction by motion. I hope this brief classification can help studying or applying colour illusions more extensively. Comprehensive classification will be fruitful in the future.

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