CHAPTER II

THEORETICAL CONSIDERATION AND LITERATURE REVIEW

2.1 Theoretical Consideration

The color appearance of objects depends on three components, light source, objects and the visual system. The light from the light source falls on the objects and is reflected. The visual system receives the reflected light and processes to perceive color of the objects.

In our daily life the composition of the light source changes from time to time and from place to place as already mentioned in Introduction of Chapter 1. Then the light composition coming from an object also changes from time to time and from space to space. Yet we need to recognize the object correctly. If the visual system perceives the color of the object faithfully as the composition of the light reaching the eye, then the color of the object changes according to the change of the light source. We can not perceive the color of the object itself and we go to bankruptcy as color of an object changes from time to time and from place to place. To overcome this problem our visual system has an ability to understand about the illumination and to discount its effect. When the light source turns to reddish as an incandescent lamp the visual system understands the illumination to be reddish and discounts the redness. Then we can perceive the right color of objects all the time and at all the places. The understanding about the illumination and the discounting the effect of the illumination change is called the adaptation to the illumination. The phenomenon that we see the right color of objects for any illumination is called the color constancy. Similarly we perceive correct lightness, and the phenomenon is called the lightness constancy. We will discuss about these two constancies next.

To explain the color constancy the concept of the recognized visual space of illumination RVSI was introduced by Ikeda et al.(2-6) and the concept will be explained in this chapter.

2.1.1 Lightness Constancy

Suppose we have a white paper and a black paper in front of us. When we look at them in the evening where not much light is available, the white paper appears white and the black paper appears black. Let us look at the same papers at daytime where much light is available. The light coming from the black paper to the eyes is much stronger than the light that came to the eyes from the white paper in the evening. Yet the former appears black. This says that the appearance of lightness does not depend on the absolute light to reach the eyes. A white paper appears white and a black paper appears black independent of the light coming from them to the eyes. This phenomenon is called the lightness constancy and an important property of the visual system.

2.1.2 Color Constancy

We know that the illumination in our environment changes from time to time. At the daytime it is the light coming from the sun. The light changes depending on the climate and the time whether in the morning, during the midday or in the evening. At night the illumination is the light coming from fluorescent lamps or incandescent lamps. Then the psychophysical color specified by the tristimulus values X, Y and Z of the object also changes according to the change of the illumination. If the apparent color of the object also changes in accordance with the psychophysical color, it becomes hard to identify the object by its color and we cannot say that the color is a part of the object.

Fortunately the color appearance of objects remains almost unchanged even if the illumination changes. A yellow mango is always yellow and it does not become an orange mango when we see it under incandescent lamps which have a lot of long wavelength light. The mango is always yellow and the yellow color is a part of the mango. That's why we can identify the mango as it is wherever and whenever it is presented to us in spite of the fact that its tristimulus values X, Y and Z change. This property of unchanging color of objects is called the color constancy and it is a property of our visual system or rather our brain. We can live safely in this world owing to this property, we may say. In the evening the light from the sun changes to orange. If there is no color constancy in our visual system, a yellow mango may become an orange mango and we may judge it too well done, a green tomato at daytime will become an orange tomato in the evening and we may pick it up to eat in error. We do not make such mistake and we see a yellow mango and a green tomato all the time. Identification of the mango and the tomato can be done without error.

2.1.3 Recognized Visual Space of Illumination (RVSI)

The concept of the recognized visual space of illumination, RVSI was proposed and developed by Ikeda and his colleagues (2-6). The concept of RVSI was introduced to express the state of an observer's recognition for a space in terms of illumination. When one enters a room he/she almost instantly understands how the room is illuminated, brightly or dimly, or whitely or a little bit reddish, and so on. This state is expressed as he/she obtained the RVSI in his/her brain, which was constructed based on what he/she saw first in the room, namely objects, windows and luminaries, which we call the initial visual information.

The most important keywords of RVSI are “recognition of space" and “recognition of illumination of the space". Only when we know the illumination of a space we can discount it from the light coming from objects and can perceive the real color of the objects.

Process of perceiving color of objects under a certain illumination is illustrated by RVSI shown by a circle as in Fig. 2-1. When a subject felt a space illuminated brightly, a large circle is drawn and when he felt a space illuminated dimly a small circle is drawn. There are three important axes in RVSI, FX, RX and IX, to explain color and color perception. FX is the fundamental axis that represents the direction of intrinsic achromatic color perception that a subject has from his birth. IX is the illumination axis that represents the color of illumination in a space. RX is the recognition axis that represents the direction of achromatic or neutral color perception. If the illumination is white IX coincides with FX as shown in Fig. 2-1a. The recognition axis also coincides with FX. But if the illumination is changed to a red color, IX is drawn at a position in a clockwise direction as shown in Fig. 2-1b. The visual system adapts to the illumination and the recognition axis RX is drawn toward IX to come close to it as shown in Fig. 2-1b. This axis RX is the direction of neutral color perception, that is, any objects to lie on the axis appears achromatic, and that the color of any object in the space is given by the angle from RX to the axis on which the object locates.

For example, suppose there is a white object in the space illuminated as in Fig. 2-1b. The light reflected from the object is same as that of illumination and the location of the white object in the illustration of RVSI of Fig. 2-1b comes on IX and close to the edge of RVSI. The angle from RX to IX is not large and the white object appears only a bit reddish. This is nothing but to say that the color constancy holds, but is not perfect. If we can have a white object in the space not illuminated by the room illumination but illuminated by a white light independent of the room illumination, the position of the object comes on FX. The color appearance of the object is determined by the angle from RX to FX and it should be very vivid green. This prediction was confirmed by Ikeda et al. (5) and by Pungrassamee et al. (1). So the illustration given in Fig. 2-1b is very useful to predict and explain the color appearance of objects in a space illuminated as IX. It must be emphasized that the recognition axis RX takes the position as shown in Fig. 2-1b only when a subject recognized the illumination, that is, only when he recognized the existence of the space.

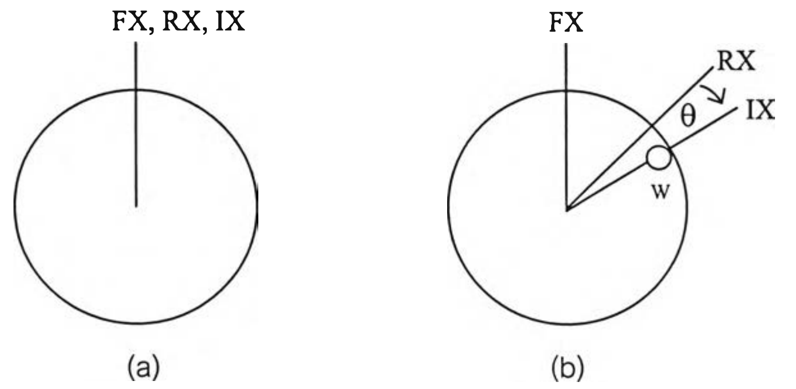

Fig. 2-1 Scheme of RVSI; FX, fundamental axis; RX, recognition axis; IX, illumination axis (a) daylight type illumination; (b) red illumination

2.1.4 Color Appearance Mode

Attribute of visual perception consisting of any combination of chromatic and achromatic content. This attribute can be described by chromatic color names such as yellow, orange, brown, red, pink, green, blue, purple, etc., or by achromatic color names such as white, gray, black, etc., and qualified by bright, dim, light, dark, etc., or by combination of such names.

Perceived color may appear in several modes of color appearance. Some of the important terms of the modes of color appearance are object color and light source color. The object color is the color perceived as belonging to an object (7), and the light source color is literally the color of a light source. In other words the light source color is the color that appears shining.

2.2 Literature Review

Ikeda et al. (4), Color appearance seen through a colored filter of various sizes.

To show that the recognition of a space determines the color appearance of an object in the space Ikeda et al. measured the color of a gray test patch through a colored filter of the size 9 cm x 9 cm or 18 cm x 18 cm. The size of the filter was 4 cm x 4 cm, which was placed on an optical bench so that it could be slided between the gray test patch and the subject. Four colored filters were employed, red, yellow, green and blue. Nine positions and eleven positions were employed for the small gray patch and large gray patch respectively. Through a colored filter a subject saw a gray patch by one eye in a room illuminated by daylight type fluorescent lamps and estimated in percentage the amount of the chromaticness perceived.

The results showed that the chromaticness was very large when the visual field through the filter is small to cover only the central part of the gray patch, but the chromaticness became very small when the visual field is large to cover the entire front view of the room. The results imply that whenever the subject could see parts of the room beside the gray test patch through the colored filter, although they might be only small in amount, the subject could construct RVSI for the space through the colored filter and perceived the original color of the test patch. When he could see only inside of the test patch through the colored filter, he could not recognize a space beyond the colored filter and he judged the color of the test patch in relation to the RVSI constructed for the room. The results confirmed the importance of the space recognition for perceiving the original color of the gray test patch.

It must be mentioned, however, that the space that the subject recognized beyond the colored filter is not exactly a different space from the subject room. It is still a part of the subject room.

Pungrassamee et al. (1), Color appearance determined by recognition of space.

Pungrassamee et al. really employed two rooms, one for a subject and the other for a test patch, and investigated whether the color appearance of a test patch placed in the test room does really change if the subject could recognize the existence of the test room beside the subject room.

The subject room was illuminated by fluorescent lamps of one of four colors, red, yellow, green and blue and the test room by the daylight type fluorescent lamps. There was opened a window between the subject room and the test room and its size was varied to one of five different sizes, W1, W2, W3, W4 and W5. With smaller windows W1 and W2 the subject could see only the test patch and the color was judged in relation to the recognition axis RX of the RVSI for the subject room. But when the window was opened to W3 the subject could see some objects in the test room around the test patch, though only a few, and he could recognize the existence of the test room. In other words he could construct RVSI for the test room with W3. The data showed that the color appearance of the test patch returned suddenly to the original color when the window was changed from W2 to W3. They clearly showed that the recognition of a space is vitally important for the color appearance.