Color Perception of Naturalistic Objects and Faces

Yoko Mizokami

Chiba Univ., -33, Yayoi-cho, Inage-ku, Chiba-shi, Chiba 263-8522, Japan

ABSTRACT

Our visual system can adapt to various changes in the color environment and maintain a stable color appearance (e.g., color constancy). The combination of multiple cues presents within objects and surroundings in a natural three-dimensional scene should contribute to color constancy. However, specular highlights would have only a little contribution. Face and skin are essential natural stimuli in our life. It has been suggested the existence of color perception specific to facial skin. We showed that reddish skin appears brighter than yellowish skin for Japanese observers, but our international comparison implies that various factors may also influence facial color perception.

1. INTRODUCTION

Our visual system can adapt to various changes in the color environment and maintain a stable color appearance. Color constancy is one of perceptual property, showing that we perceive the stable color of objects even if the reflected light changes depending on illumination color [1].

To understand color constancy in real life it is essential to conduct experiments within real three-dimensional (3-D) space. Color constancy is generally better and more stable for 3-D stimuli compared with two-dimensional (2-D) stimuli. We showed that monocular viewing with limited view and motion parallax designed to make a 2-D scene appear more like a 3-D scene improved color constancy in the image [2]. This suggests that the combination of various cues present within the object and environment, and the recognition of space, illumination and objects, should contribute to establishing good and stable color constancy.

Face and skin is also one of most important natural stimuli in our life, and skin color is essential for obtaining various information on our body and mind, such as health, age, and face impression. Therefore, we must have developed visual sensitivity tuned to skin. It has been suggested the existence of color perception specific to facial skin. For example, it has shown that sensitivity to changes in reddish direction of the skin is better than other color directions. Reddish skin looks brighter than yellowish skin even if they have the same lightness [3].

Here, I introduce two topics on color perception on naturalistic stimuli. The first topic is the influence of surface property on color constancy for familiar objects. The second topic is an international comparison of the brightness perception of facial skin.

2. INFLUENCE OF SURFACE PROPERTY ON COLOR CONSTANCY

2.1 Objective

One of the critical factors influencing color constancy would be the richness of cues. It has been in discussion on the contribution of specular reflection occurring on the glossy surface of an object because different researches showed contradictive results. This contradiction would be due to a difference in stimuli and viewing conditions. Here, we examine the effect of the surface and specular reflection of objects on color constancy using vegetables as familiar objects in real space.

2.2 Experiment

We built a booth arranged like an ordinary room illuminated by either whitish or reddish. We used three types of familiar vegetables as stimuli. They had a surface with two gloss types: a gloss and a matte surface. Figure 1 shows the stimuli used in the experiment. An elementary color naming method was used for evaluation. Normal view and limited view conditions were tested. In the limited view condition, observers viewed a stimulus only through a tube.

Observers evaluated stimuli with different glossiness under white and reddish color illumination, and we compared those color appearances.

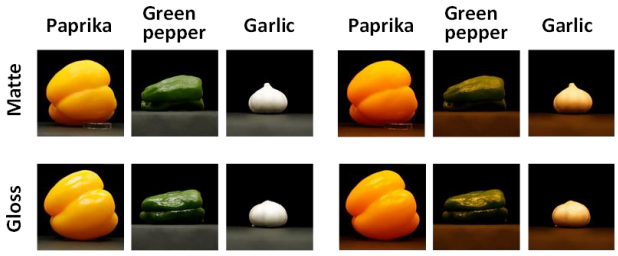

Fig. 1. Stimuli under the white and reddish light

2.3 Results

Figure 3 shows the response shift showing the intensity of color constancy under each condition. Color constancy is higher in the normal view condition than the limited view condition. Color constancy is stronger for the gloss surface than the matte surface. This trend is more apparent in the limited view condition. The results showed that while specular highlights barely contribute to color constancy under a normal viewing condition with real 3-D objects in the real 3-D environment, a small contribution was

observed under limited viewing condition, under which only an object was observed in isolation, without any surrounding information.

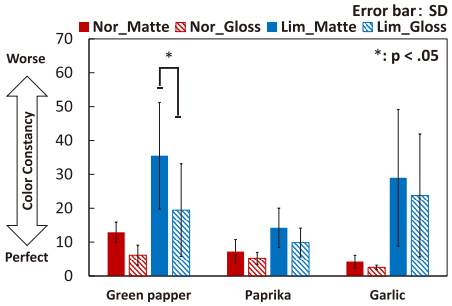

Fig. 2. Strength of color constancy (perceptual color difference in white and reddish light)

These results imply that a specular cue for color constancy would be revealed only under specific conditions in which other cues, such as surroundings and object shape, are not available, and the highlight region is recognized as a specular component. The contribution of specularity to color constancy may be buried under conditions that include other rich cues for illumination.

3. BRIGHTNESS PERCEPTION OF FACIAL SKIN

3.1 Objective

The skin color distribution of young Japanese women measured with a colorimeter showed a trend that yellowish skin had higher lightness compared to reddish skin. On the other hand, it was shown that reddish skin appeared brighter than yellowish skin when both had the same lightness [3]. However, the previous result was obtained from the experiments using Japanese faces with Japanese skin color and for Japanese observers. Skin color varies among different ethnic groups, from dark to light, and from yellowish to reddish. It is not clear how the brightness perception of facial skin is influenced by the diversity of skin face colors and observers. Here, we investigate the brightness perception of facial skin for Japanese, Thai, and Chinese observers.

3.2 Experiment

We used a young Japanese female face, which was an average of forty female faces. We prepared test faces with four skin color types that were the average skin color of Japanese, Thai, Caucasian, and African. Figure 3 shows an example of stimuli with Japanese skin color. The skin color of each face was modified by changing the ratio of L*, a*, b* from each test face. Test images with constant lightness and different hue angles were generated. Scale images had the same hue angle corresponding to an original face color of each skin color type and different lightness. A test image and a scale image were presented side by side on a color-calibrated tablet display. Observers adjusted the lightness of facial skin on the scale image to match the brightness of the test image with the scale image. They evaluated four groups of stimulus images, three times each. We conducted experiments in Japan and Thailand.

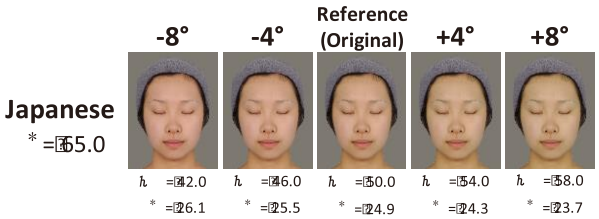

Fig. 3. Example of modulated images (Japanese)

3.3 Results

As shown in Figure 4, Japanese observers showed a trend that reddish skin appeared brighter than yellowish skin, consistent with the previous study. In contrast, Thai observers showed an opposite trend, and Chinese observers did not show the systematic influence of hue. They suggest diversity in the brightness perception of facial skin.

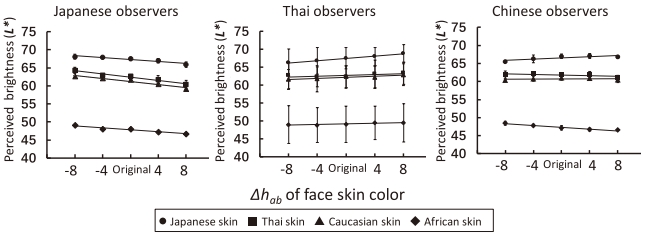

Fig. 4. Results of brightness perception of Japanese, Thai, and Chinese observers

4. CONCLUSION

It is important to investigate color perception for natural objects in the natural environment. The combination of various cues in objects and environments would contribute to stable color perception. However, the weighting of each cue would be different, such as a small contribution of specular highlights. Face and skin are also important natural stimuli in our life, and we would have color perception specific to facial skin. An international comparison of brightness perception of facial skin implies that various factors such as facial color distribution, ethnicities, environments, and cultures may also influence facial color perception.

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