Brightness size of RVSI of 3D scenes

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ABSTRACT

The human perception of a natural scene is three-dimensional (3D) whereas a printed picture is perceived as two-dimensional (2D). Therefore the light source in the printed picture is not noticed as a real light source as it is in the natural scene but an object. It was assumed that the color appearance perception of 2D and 3D scenes under identical illumination is different. To explain the color appearance perception, the concept of recognized visual space of illumination (RVSI) which is an understanding of the state of illumination of a space is applied. The investigation of brightness size or the intensity of the illumination of RVSI of 2D and 3D scene which can be determined by the border luminance is the objective of this paper. Two borders luminance between object colour and natural color light source, and that between natural color light source and shining light color source of a 2D scene were determined. The 5 different printed pictures and their 5x5 cm. jumbled pieces were employed as 3D and 2D perception respectively and the narrow viewing condition was set to achieve 3D perception. Five observers were asked to determine two borders by looking at the pictures in which a small hole was made and the selected test patch was installed behind the hole. In the case of two night scenes and one early morning scene that had low illumination in the real scenes, the border luminance between object colour and natural light color source (${}_{o}B_{n}$) of 2D perception was obviously larger than that of 3D perception. The border luminance of the same scenes between natural light color source and shining light source (${}_{n}B_{sh}$) of 2D was bigger than 3D, but it was insignificant. On the contrary, the ${}_{o}B_{n}$ and ${}_{n}B_{sh}$ of 2D perception of the day scene picture were significantly smaller than ${}_{o}B_{n}$ and ${}_{n}B_{sh}$ of 3D perception.

Keywords: recognized visual space of illumination (RVSI), Brightness size of RVSI, space recognition, 3D scene.

1. INTRODUCTION

Two-dimensional (2D) printed pictures of the scenes that capture strong perspective depth appear to be three-dimensional (3D) as an observer's angle view is made narrow. In addition to the angle view, an adjustment of the illumination illuminated in the picture's room can promote strong 3D perception. This is caused by functions of the human brain. Some research has adjusted a viewing angle to allow observers perceived 3D perception[1-2]. Mizokami *et al*. investigated the difference of color constancy when observers perceived a scene as 2D and 3D using the jumbled picture technique to change the perception of 3D to 2D[1]. In this research such a technique was employed. An understanding of how much and what color of an illumination in an environment affects a color appearance perception of a surface color is called Recognized Visual Space of Illumination, RVSI. This concept was developed by Ikeda[3]. The intensity of the illumination in the environment indicates the brightness size of RVSI and it can be determined using the border luminance between object color and unnatural color. Yamauchi *et al*. investigated only one boarder luminance between object color and light source color and the jumbled picture technique to change the dimension was not used[4]. According to the concept of RVSI, we assume that the border luminance between object colour and natural light source color, and that between natural light source color and shining light source color of a 2D scene differ from those of a 3D scene, if the illumination in the room is kept the same. In the experiment the two borders of a 2D scene and a 3D scene will be determined.

2. METHOD

2.1 Apparatus

The experimental booth was built and partitioned with black cloth and wood board into a subject room, a stimulus room and a test chart room as shown in Figure 1. No illumination in the subject room and the window of the subject room could be adjusted to let an observer see the depicted perspective depth of the printed picture attached in the stimulus room. The observer was able to control the luminance of the test chart room by a control box in the room. The amount of light incident on a surface of the entire picture in the stimulus room was set to obtain a uniform distribution on the picture. A small square hole was made in the picture and the observer could see the test chart through the hole. The picture holder could be adjusted to ensure that the position of the hole of all pictures did not change. This resulted in control of the eye position of the observer to be the same while viewing the test chart through the picture hole.

2.2 Procedure

Five printed pictures were selected to cover the scene of atmosphere from dawn to dusk and artificial light scene in a house as shown in Figure 2. The most important criterion was the scene of the printed picture, which must be easily perceived in 3D when the visual field was limited. To observe as a 2D perception, the printed picture was cut into pieces of 5x5 cm in size, jumbled and pasted on a board. The piece of the printed picture where the hole was made, was pasted on the board at the same position of the non-jumbled picture. The example of picture 4 and its jumbled version were shown in Figure 2. Two test charts of N8 and 7.5YR8/6 were chosen to simulate the object color and light source color of the printed picture when viewed through the picture. In some cases, filters were required to reduce the brightness of the test chart if it appeared too bright for the scene. Five subjects, 3 females and 2 males, aged between 22-71, observed with one eye the following instructions. The subject was asked to set three levels of the perception of the scenes when the subject perceives 3D. First, the subject determined “The object color of the scene under that illumination”. Second, the subject determined “The natural appearance of the light of that scene under that illumination”. Third, the subject determined “Shining light”. The subject was asked to set only two levels of perception of jumbled pictures for both day and night scenes as the first and third perception of 3D scenes.

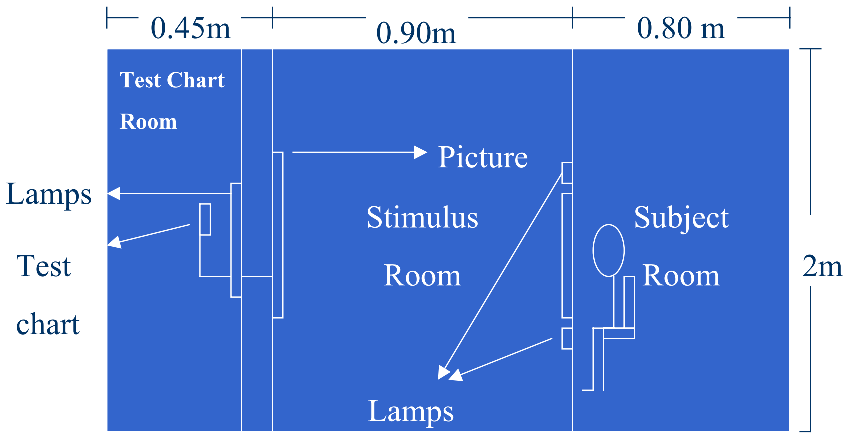
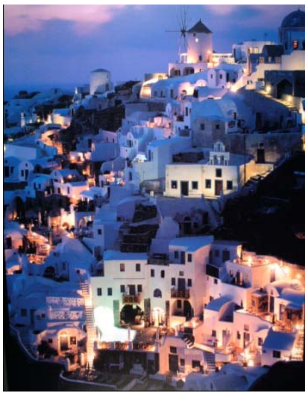


Figure 1: Scheme of apparatus.

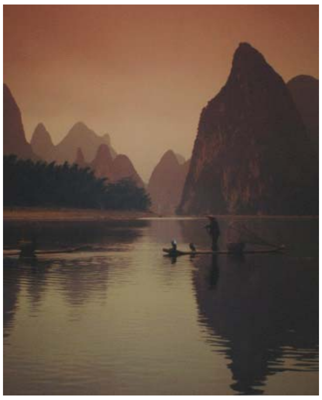
3. RESULTS

Five printed pictures were P1 (Night scene), P2 (Night scene), P3 (Early morning scene), P4 (Day scene) and P5 (in house scene). Therefore, the brightness size of the scenes perceived as 3D was different depending on how the observer felt the brightness of the atmosphere in the real scene. In the day scene of P4 the observers determined only two borders because the natural appearance of the artificial light source did not fit to the day scene and two holes were made, one on a bright area and another on a shadow. The average of the determined borders of 3D perception is shown in Figure 3. The object color appearance of each picture was different since the observer determined it as the same appearance of the color nearby the hole, however, the distance between “natural appearance of light” and “shining light” of P1, P2 and P3 was approximately the same. This also applied to the distance between “object color appearance” and “natural appearance of light”. The two areas of P4 gave about the same distance of the border between “natural light” and “shining light”, whereas the borders determination of the P5 scene was far more different. The in-house scene, P5 was shot in a Japanese style living room under an incandescent lamp. With this circumstance, observers perceived object color brighter than natural light. When 3D perception was destroyed, the border luminance from object color to shining (${}_{o}B_{sh}$) of P1, P2 and P3 increased significantly as shown in Figure 4, and it was about the same distance as the ${}_{n}B_{sh}$ in the 3D perception scene. However, the determination of the shining appearance did not have a significant change for the low light scenes (P1, P2, P3 and P5). The border luminance of shining in the 2D-day scene (P4) of both shadow and bright areas decreased significantly compared to the 3D scene. Subsequently it gave ${}_{o}B_{sh}$ about the same for all scenes.

The new findings of this research were: the 3D and 2D perception of different printed picture scenes gave the difference in the boarder luminance, and the brightness size of RVSI of 3D perception, which was determined by the boarder luminance, was not smaller than that of 2D perception in all cases. The exception was in the case of day scene which had high illumination in the real scene. The result of Yamauchi *et al.*[4] showed only the brightness size of RVSI of 3D perception of night scene which was small as subjects gave the brightness of Munsell N8 as the light source color. In this research we used only one day scene printed picture, therefore, in the future work the investigation of the brightness size of RVSI of a number of day scene printed pictures will be carried out.



P1



P2

P3

P4

P5

Jumbled of P4

Figure 2 Printed pictures used in the experiment (P1-P5) and an example of jumbled of P4 (Day scene).

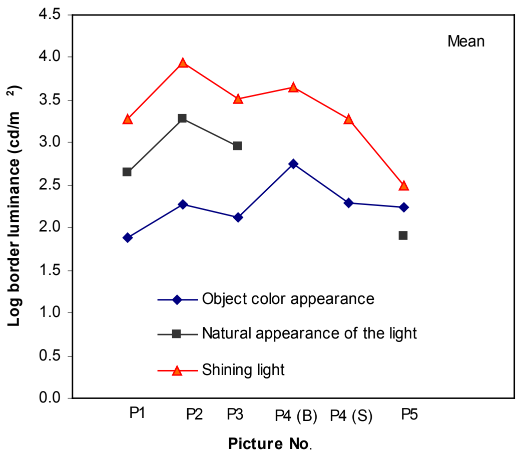


Figure 3: Border luminance of 3D perception scene.

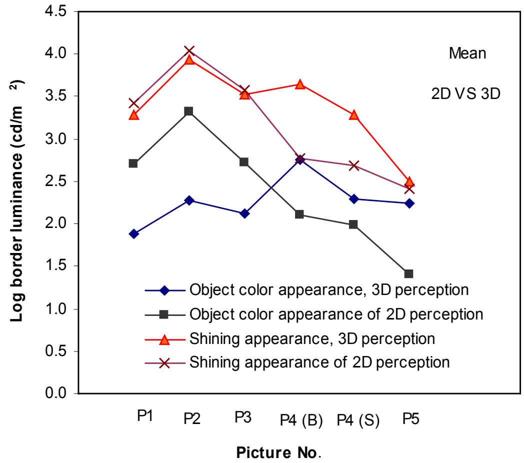


Figure 4: Comparison of the border luminance of 3D and 2D scenes.

4. CONCLUSION

The brightness size of RVSI of 3D perception is smaller in the outdoor scene with low illumination presented in the real scene but larger in the scene with high illumination presented in the real scene. On the contrary, the ${}_oB_n$ and ${}_nB_{sh}$ of 2D perception of the day scene picture were significantly smaller than ${}_oB_n$ and ${}_nB_{sh}$ of 3D perception.

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