# Relationship between pictorial cues for depth perception and perceived vanishing points in pictures

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## Abstract

Some researchers have investigated differences between the impression on landscape photographs and that formed at these real scenes. These results have led to a development of image rendering technology for computer graphics. In a previous work, our research group found a difference between vanishing points of perspective images and perceived vanishing points in a real space. We thought that changing the position of vanishing points in pictures according to our perception may be a key for representation of our perception in computer graphics. In this study, our purpose is to investigate the relationship between pictorial cues for depth perception and perceived vanishing points in pictures. For the experiment, we prepared the several pictures that were controlled pictorial depth cues and positions of vanishing points. The observers were directed to draw the position of perceived vanishing point on an answer sheet. The results showed that perceived vanishing points in pictures were different from the pictorial vanishing points.

***Key words***: *vanishing points, pictorial cue, optical illusion, perspective image, photograph.*

## Introduction

There are the difference between the impression on landscape photographs and that formed at these real scenes [1-2]. Our research group paid attention to position of vanishing points [3]. In perspective images, any parallel lines in a real space cross at one point called vanishing point. However, Hokusai Katsushika who is a very famous ukiyoe artist leaved a drawing technique that taught controlling the position of vanishing points in images for representation of the scene [4]. We investigated the position of vanishing points perceived in real space [3]. Figure 1 shows perceived vanishing points in a corridor scene. The four parallel lines in the corridor cross one vanishing point (doted lines in Fig.1), but the observers answered different positions in each pair of parallel lines, the ceiling, the floor, the right wall, and the left wall (solid lines in Fig.1). Then, we generated non true perspective images which were controlled positions of vanishing points in the images according to these results. And we conducted a subject experiment to compare the impression of these image and that formed in the real space. The results of experiment showed that the generated images were not evaluated better than the

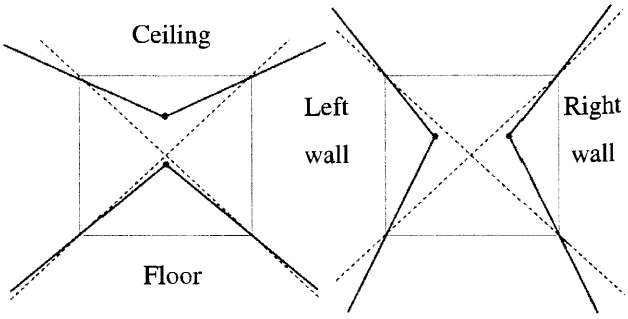


Figure 1. Gaps of perceived vanishing points in a corridor scene. The center of square is the correct position of the vanishing point.

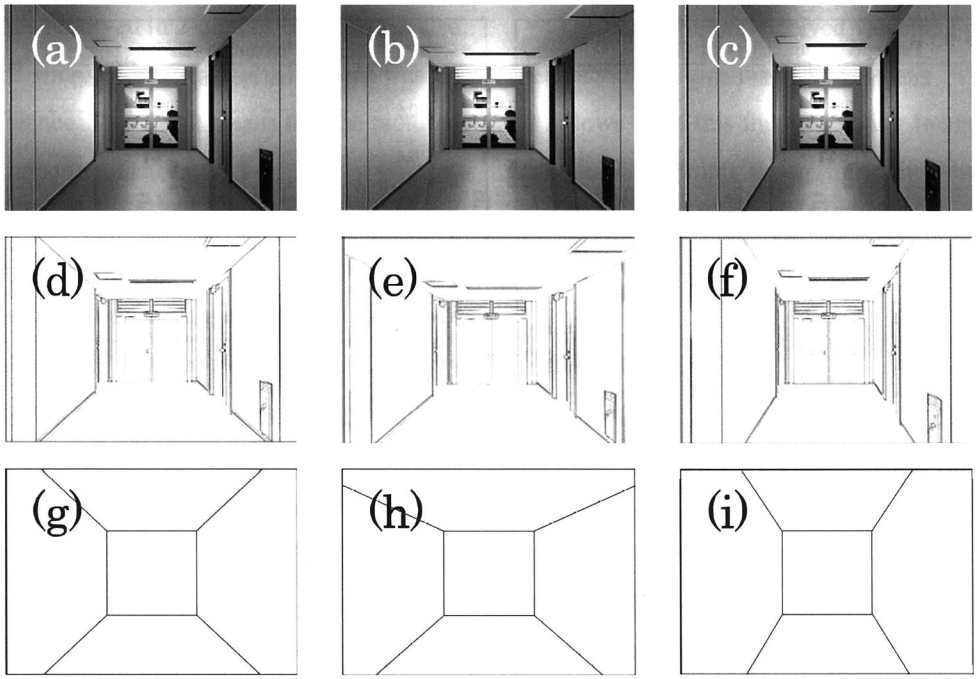


Figure 2. Prepared images for the experiment. (a), (d), (g) are the perspective images. (b), (e), (h) are changed the vanishing points of the ceiling. (c), (f), (i) are changed the vanishing points of the right and left wall.

perspective image significantly. Though these images have the same vanishing points as our perceived position, why can these images not impress us more reality? In this study, we supposed that our vision might evaluate the different position of the vanishing point in 2-dimensional images also, and we investigated the relationship between pictorial cues for depth perception and perceived vanishing points in images.

## Experimental Method

At first, we prepared three images. The first one was a true perspective image drawing a corridor scene (Fig. 2(a)). The second and third were generated by controlling positions of the vanishing points (Fig. 2(b) and (c)). The second one was changed the vanishing point of the ceiling according to our previous study [3]. The third one also was changed the vanishing points of the left and right walls according to the study [3]. In addition, we generated more 6 images which were changed pictorial depth cues from the original images (a)(b)(c). These images represented edge lines of the corridor scene. Images (g)(h)(i) were simpler than images (d)(e)(f). All images were 89 by 127mm, and put on a black paper. The observers were 10 university students, 5 males and 5 females, aged 21-28 years. The observer sat down on a chair. The experimenter showed an image to the observer by random order. The images were put at a distance of 35cm in front of the eye. At each image, the observers draw 4 points described in the followings on answer sheets.

- The vanishing point of two boundary lines between the ceiling and the both walls are crossing. (vanishing point of the ceiling)
- The vanishing point of two boundary lines between the floor and the both walls are crossing. (vanishing point of the floor)
- The vanishing point of two boundary lines between the right wall and the ceiling, between the right wall and the floor are crossing. (vanishing point of the right wall)
- The vanishing point of two boundary lines between the left wall and the ceiling, between the left wall and the floor are crossing. (vanishing point of the left wall)

The answer sheet was drawn a rectangle of 3.6 by 3.9cm, that is the aspect ratio of the front wall of the image (Fig.3). The Observers draw each vanishing point three times for one image.

## Results

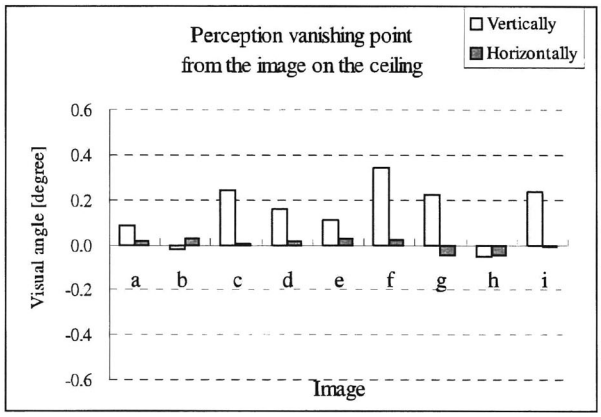


Figure 3. Deviation of perceived vanishing point (the ceiling)

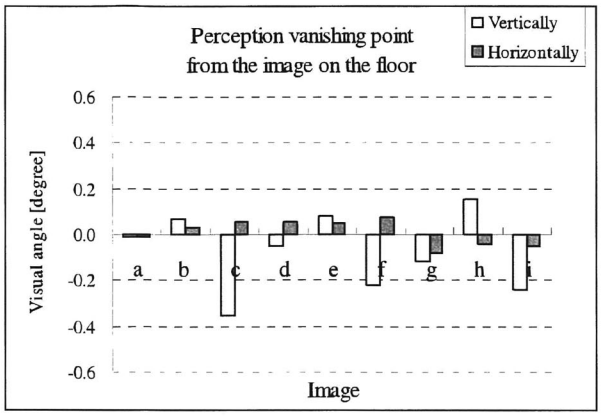


Figure 4. Deviation of perceived vanishing point (the floor).

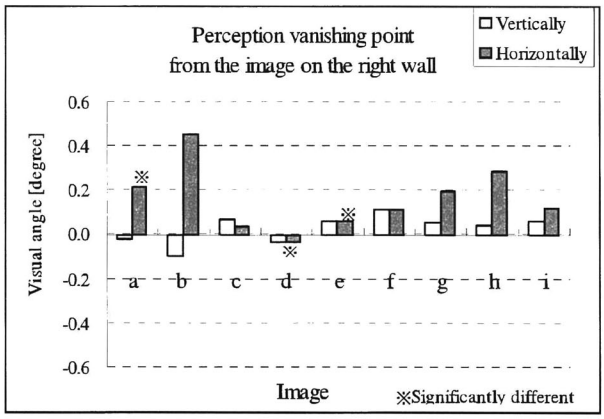


Figure 5. Deviation of perceived vanishing point (the right wall).

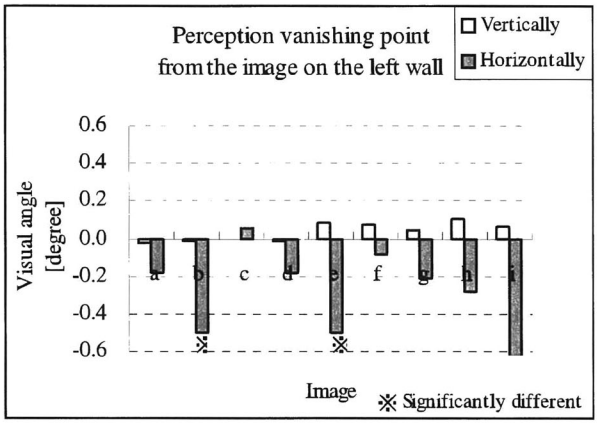


Figure 6. Deviation of perceived vanishing point (the left wall).

We measured the perceived vanishing point on each answer sheet, and calculated horizontal deviation and vertical deviation of the perceived point from the true one. Then we converted the distance to the visual angle. Figures 3-6 show the gaps in each image. The plus value in the figures means upper ward in vertical deviation, righter ward in horizontal deviation, and vice versa. An analysis by using the 95% confidence limits revealed that the perceived vanishing points in the following images differ from the true point significantly.

· Image (a): The vanishing point of the right wall (horizontal deviation). The upper confidence limit was 0.3 degree and the lower one was 0.1 degree. The true position of vanishing point, deviation 0.0 degree, was not included in the section.

· Image (b): The vanishing point of the left wall (horizontal deviation). The upper confidence limit was -0.3 degree and the lower one was -0.8 degree.

· Image (d): The vanishing point of the right wall (horizontal deviation). The upper confidence limit was 0.4 degree and the lower one was 0.1 degree.

· Image (e): The vanishing point of the right wall (horizontal deviation). The upper confidence limit was 0.9 degree and the lower limit was 0.3 degree. The vanishing point of the left wall (horizontal deviation). The upper confidence limit was -0.2 degree and the lower limit was -0.8 degree.

## Discussion

In images (a)(b)(d)(e), the perceived points have been significantly different from the true vanishing point on each image. Our previous study [3] has reported the deviation of perceived vanishing point in a real space. This results show that the deviation of perceived

vanishing point is observed in 2-dimensional images also. However, in the simplest images (g)(h)(i), there was no significant difference. This result means that the pictorial depth cues are important factor.

In the images (c)(f) also, there was no significant difference. These images have the same cues of the depth as images (a) or (d), but the angles of both walls are different. It seems that these angles of lines also may affect the position of perceived vanishing point.

The deviation of perceived vanishing point depends on the location of the parallel lines. The perceived vanishing points of the ceiling and floor didn't show significant difference in all images. Our previous study [3] has reported difference of the perceived vanishing point depending on the parallel lines in a real scene (Fig.1). In this point, it seems that the deviation of perceived vanishing point in 2-dimensional image relates to that in real space.

## Conclusions

In this study, the results showed the following points.

- In some cases, we can observe the deviation of perceived vanishing points in 2-dimensional images.
- The deviation of perceived vanishing points probably depends on the pictorial cues for depth perception.
- The deviation of perceived vanishing points probably depends on the location of lines.

It follows from this that generating images by changing the vanishing points according to the perceived position in real space is not enough for reproduction of the real impression in images.

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