《연구논문》

VISUAL ILLUSION STRENGTH IN STATIC AND DYNAMIC FIGURES

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ABSTRACT

This paper concerns with the visual illusion strength for the static and dynamic figures which are generated on computer CRT. The Vertical-Horizontal, Ponzo, and Müller-Lyer illusion are studied under various conditions of type, size, and background angle of figure. And the results are obtained through the Multivariate Analysis of Variance(MANOVA). This paper concludes that the size and background angle of figure generally effect on the visual illusion, and there is a significant difference between figure types. These results can be applied to eliminate the visual illusion in real design.

Keywods:Visual illusion strength;Static and dynamic figure;
Vertical-horizontal illusion;Ponzo illusion;Müller-Lyer illusion

1. Introduction

It is known that the distal stimuli of objects are formed two-dimensional images on the surface of retina. In this process, usually we perceive the object constantly despite of changing the distance between human's eye to the object and the movement of eye itself. There are many opinions how the perception of an object can be constant while the stimulus varies. It is generally accepted that there is a perceptual constancy in perceptual process.

The visual illusions are caused by the information processing mechanisms, not the eye itself. The visual illusion can not be explained clearly yet, but it is limitedly due to the process of size constancy, the influence of the social and cultural factors, the correcting process of retinal blur, and so on.

Size Constancy

Somehow the distance and depth cues of the target backgrounds are taken into account and the size percept is

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adjusted. In other words, we estimate distance and size together. This suggests that changes in apparent distance should alter our perception of apparent size. It has been conflicted with psychologists if the size constancy is due to innateness or the experience and learning. But as most perceptual constancies are based on prior experience and learning, many workers stated that it is acquired by experience and learning(Coren *et al.* 1979).

A typical example related to the size constancy is the Moon illusion(Kaufman and Rock 1962). In Müller-Lyer illusion as in Figure 1, the visual illusion for size does not appear if wings as the distance and depth cues are absent.

Social and Cultural Factors

People in industrialized countries generally have better acuity for horizontal and vertical lines than they do for lines oriented at an angle. Because they live with houses and buildings constructed with straight lines, corners, and right angles. One explanation for this differential acuity is the 'carpentered environment hypothesis,' which suggests that the perception of industrialized people are influenced by this social and cultural factors. This carpentered world concept is also used to explain why industrialized people are more susceptible to visual illusions such as the Müller-Lyer illusion than the people from non-industrialized countries(Huffman *et al.* 1987).

Retinal Blur

The visual percept is possible with the image after it passed through the cornea and the crystalline lens of the eye, and has finally been projected onto the surface of the retina. When we discussed visual acuity, the eye is not a perfect image-forming system. The optics are actually rather poor.

Considering that the blurred lines are brightest in the middle and getting darker toward the edges. The blurred line on the retina stimulates fewer and fewer receptor cells as one move out from the center of the line to its edges. The visual system accommodates the region in the image where the stimulation is the most intense and then treats this region as if it were the actual location of the line. This would explain why the world usually looks sharp and clear despite the fact that the image itself is blurred.

Consider the Müller-Lyer illusion whith somewhat thick and blurred lines. When two lines of a wing(an arrowhead) meet at an angle, the edges of blurred contours can overlap on the retina because the blurred contours are coming close to on another. This could lead to a ridge of maximum stimulation where the blur from the two adjacent lines overlaps rather than where the centers of the two lines are located. When this happens for an angle, it appears slightly more obtuse and the apparent location of the angle vertex is displaced into the body of the angle. This is a factor that Müller-Lyer illusion strength is greater when the figure is blurred. In general, a given illusion increases its strength when it is optically blurred and decreases its strength when special optical procedures are used to reduce the image blur in a normal eye(Coren *et al.* 1979).

The visual illusions are rarely appeared in the eye measurement. If they are appeared in existed sufficient visual information, the illusion could not cause any stmospheric observations when the visual information is insufficient and influenced by the including backgrounds such as illusion figures, and so on.

In this research, 2 types of Vertical-Horizontal, 2 types of Ponzo, and one type of Müller-Lyer illusion figures generated on CRT are used to find the effects of changes in type, size, and background angle of the figures. The visual illusion strength of the subjects are analyzed and summarized statistically.

2. The experiment for visual illusions

2.1 Experiment design

The basic 36 figures for the 5 types of visual illusion to be used in this experiment as shown in **figure 1**are generated on CRT. The proportions of the length or size of 'b' to 'a' represent the visual illusion strength.

The conditions of visual illusion figures and the method of the experiment are as follows.

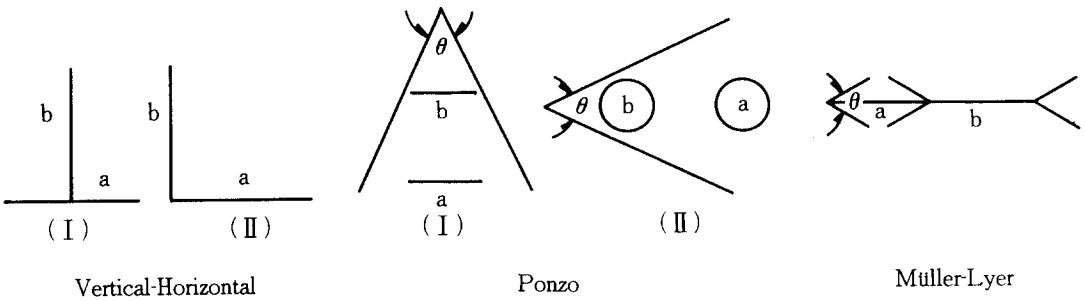

Figure 1. The prototypes of visual illusion figures for the experiment

2.1.1 Static figures

The conditions of 15 Static illuson figures are provided in **Table 1.** Each figure takes 6 different proportions in the length or size of 'b' to 'a' such as 60, 70, 80, 90, 100 and 110%, respectively. They are shown to the subjects at the same time on CRT, and then a figure to be perceived same 'a' and 'b' is selected. The proportion of the length for the selected figure is tested as the visual illusion strength.

Table 1. Experimental Conditions for static figures

Figure Conditions / Figure Types	Length and size (cm)	Background angle (degree)
Vertical-Horizontal(Ⅰ)	3.5, 4.5, 6.0	—
Vertical-Horizontal(Ⅱ)	3.0, 4.5, 6.0	—
Ponzo(Ⅰ)	1.8	40°, 50°, 60°
Ponzo(Ⅱ)	Circle D =1.5	40°, 50°, 60°
Müller-Lyer	3.0	40°, 50°, 60°

2.1.2 Dynamic figures

The Conditions of 21 dynamic illusion figures are shown in **Table 2.** An illusion figure is displayed on CRT with a given background angle, length and/or size as 'a' at a time, then a subject increases and decreases the length or size of 'b' on same CRT by keying to match it to 'a'. He/she stops keying as soon as he/she feels the 'b' is same as the 'a'. The proportion of the 'b' to 'a' is defined as the visual illusion strength.

Table 2. Experimental Conditions for dynamic figures

Figure Conditions / Figure Types	Length and size (cm)	Background angle (degree)
Vertical-Horizontal(Ⅰ)	3.5, 4.5, 6.0	—
Vertical-Horizontal(Ⅱ)	3.0, 4.5, 6.0	—
Ponzo(Ⅰ)	2.0, 2.5, 3.3	40°, 50°, 60°
Ponzo(Ⅱ)	Circle D =1.8	40°, 50°, 60°
Müller-Lyer	3.0, 4.5, 6.0	40°, 50°, 60°

2.2 Subjects

60 undergraduate and graduate students are examined for 3 days in this experiment. They are aged between 20 and 35, and consist of 47 males and 13 females. The experiment is done in day time for natural lighting.

2.3 The Experimental Factors

The differences of the illusion strength with the effect of sex, age, visual acuity, and spectacles are tested through the MANOVA(Multivariate Analysis of Variance) of 36(figures) × 4(effects). Also, the differences of the average illusion strength with static and dynamic figures, different length or size of figures, and background angles are tested through MANOVA. The CRT used in this experiment has the size of 12 inch and the resolution of 600-400 monochrome.

3. The results of the experiment

The differences between sexes, ages, visual acuities, and spectacles in visual illusion strength are not significant as in the preliminary experiment. It seems that the visual illusion is not due to the human characteristics of the intrinsic factors such as the above, but backgrounds and types of figures. A significant difference is found between figure types. The visual illusion strengths for each illusion figure are shown in **Table 3.**

The illusion strength of Ponzo(Ⅱ) figure for the size of circle is scarcely appeared as shown in **Table 3.** This indicates that the illusion strength for the size of a circle is smaller than for a line.

The order of visual illusion strength for the dynamic figures is shown in **Table 4.** In general, Vertical-Horizontal(Ⅰ) and Müller-Lyer illusion strength having acute angles such as 40° and 50° are comparatively greater than the others.

Comparing the illusion strength between the static and dynamic figures in the same type, the strength of the dynamic figures is smaller than the static figures except the Ponzo(Ⅰ) illusion. When the subjects continuously increasing or decreasing the length or size of figures, they are continuously adjusting the length. Therefore, the visual illusion strength for dynamic figures is smaller than for the static figures. It is assumed that the illusion strength for the static figures is smaller than the dynamic figure, because the background angle becomes the standard point of comparison of the length in the static figure of Ponzo(Ⅰ) illusion.

In Vertical-Horizontal illusion, the illusion strength of the type Ⅰ is much greater than the type Ⅱ, and the effect of figure size on the illusion strength is not constant. When the smaller background of angle is used with

Table 3. Illusion strength of each figure type

FIGURE TYPE (figure conditions)	STATIC M(%)	STATIC S.D(%)	DYNAMIC M(%)	DYNAMIC S.D(%)
1. VERTICAL-HORIZONTAL(Ⅰ)				
a: 3.0	79.5	11.7	80.0	10.0
a: 4.5	77.0	8.9	83.1	12.1
a: 6.0	80.3	9.0	82.6	11.6
2. VERTICAL-HORIZONTAL(Ⅱ)				
a: 3.0	93.2	6.5	95.6	5.2
a: 4.5	92.0	5.8	93.4	5.7
a: 6.0	92.3	4.6	92.2	6.0
3. PONZO(Ⅰ)				
θ : 40	88.2	6.0	85.8	6.0
θ : 50	91.0	5.7	87.5	5.7
θ : 60	91.0	5.7	89.9	5.5
4. PONZO(Ⅱ)				
θ : 40	95.5	8.5	95.0	3.9
θ : 50	99.0	6.8	97.7	3.8
θ : 60	101.0	8.6	97.9	3.6
5. MULLER-LYER				
θ : 40				
a: 3.0	73.8	10.7	78.4	9.0
a: 4.5	—	—	79.0	8.5
a: 6.0	—	—	80.0	8.6
θ : 50				
a: 3.0	74.7	10.8	79.2	9.5
a: 4.5	—	—	81.5	8.6
a: 6.0	—	—	82.4	6.7
θ : 60				
a: 3.0	78.8	8.8	80.2	8.8
a: 4.5	—	—	83.2	8.4
a: 6.0	—	—	83.2	6.8

a:length (cm), θ :background angle(degree)

Table 4. The order of visual illusion strength for the dynamic figures

Figure	Conditions	Visual illusion strength order
Müller-Lyer	(θ =40, a =3.0, 4.5)	V-H(Ⅱ) → Ponzo(Ⅰ) → V-H(Ⅰ) → Müller-Lyer
V-H(Ⅰ)	for all conditions	
Müller-Lyer	(θ =40, a =6.0) (θ =50, a =4.5, 6.0) (θ =60, for all a)	V-H (Ⅱ) → Ponzo(Ⅰ) → Müller-Lyer → V-H(Ⅰ)
V-H(Ⅰ)	(for all θ, a =3.0)	
Müller-Lyer	(for all θ, a =4.5, 6.0)	
V-H(Ⅰ)	(θ =50, a =4.5, 6.0)	

Ponzo(Ⅰ), the greater illusion strength is detected. In Müller-Lyer illusion figures, it is revealed that smaller size of figure and smaller background angle cause the greater illusion strength.

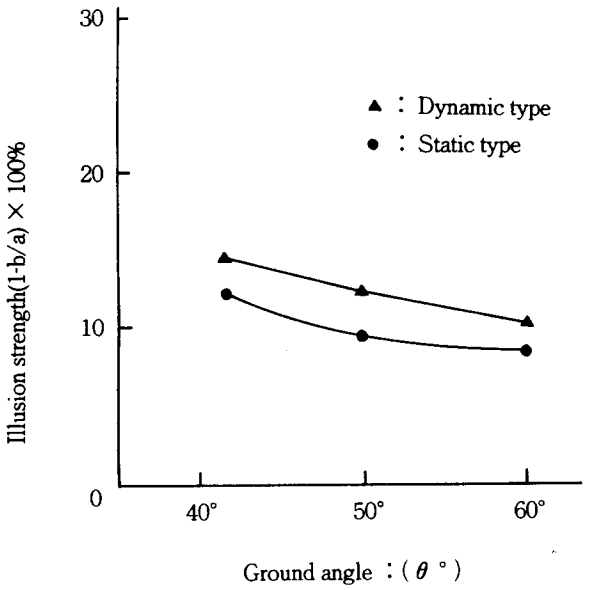

Figure 2. The effect of figure ground angle on ponzo(Ⅰ) illusion strength

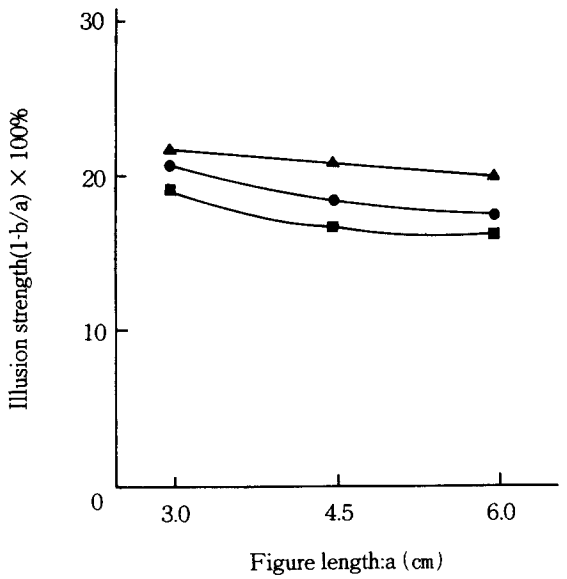

Figure 3. The effect of length and ground angle on Müller-Lyer illusion strength(dynamic type)

4. Conclusions

It is confirmed statistically through the preliminary experiment that differences between the intrinsic factors such as sex, age, visual acuity and spectacles are not significant in visual illusion strength. But Coren and Girgus(1978) stated that ages effect on the illusion strength in Ponzo. Therefore, it can not be assumed that the aged person could have simply more chances of having the experience and learning of the distance and depth cues which causes visual illusion. The illusion strength of Müller-Lyer and Vertical-Horizontal(Ⅰ) illusion is greater than the other 4 types inthis experiment. In general, the illusion strength of dynamic figures in same figure type is smaller than the static figures. When the angle of background is small, the illusion strength is greater in Ponzo(Ⅰ). Also when background angle and length of figure is smaller, illusion strength is greater in Müller-Lyer illusion. This result agree with the study of S. Richardson, L.L. Chan, A. Lee, and S.T. Teo(1972). In Vertical-Horizontal illusion, the illusion strength of type(Ⅰ) is greater than type(Ⅱ). In this case, the visual illusion possibly caused by the distance and depth cues can not be explained formally.

The visual illusion strengths for some static and dynamic figures as shown in **Table 3** and **4** can be applied in opposition to eliminate the illusions in real design stages.

It is necessary to examine individual figure closely before applying the suggestions in practice since visual illusion could be influenced greatly by the shape of figure and background. It is recommended to study various visual illusions with complex figures not like the simple ones as in this experiment, because the figures and backgrounds on CRT are very complex in reality.

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