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DIFFERENCE OF SHAPE CONSTANCY IN UPPER AND LOWER VISUAL FIELDS

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1. ABSTRACT

Functions of human vision have been developed to adapt to ecological restrictions. Especially, the position in early vision is neurophysiologically different between objects in the upper visual field (UVF) and in the lower visual field (LVF). In recent years, we have studied the relationship between shape constancy and eye movement. In this study, we investigate differences of shape constancy in the UVF and in the LVF.

We performed psychophysical experiments using three types of boards (circle, square and lozenge: square turned 45 deg.) as comparison stimuli and graphic patterns on a CRT as standard stimuli. The perspective shape was displayed on the CRT as if it was inclined at angles of 10, 25, 35, 45, 55, 65 and 80 deg, respectively. Subjects were asked to actually make the shape equal to the pattern on the CRT.

The results of the test determined by the difference between two mean values show a difference at a significance level of 2.5% between the UVF and the LVF. Subjects exhibited the tendency to look at the upper end of the stimulus in case of the UVF but not in the case of the LVF.

2. INTRODUCTION

When we observe objects inclined toward us, we see them not as shapes indicated by the laws of perspective but as the shapes these objects 'really' possess. This charac-

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teristic of perception is called 'shape constancy.' In recent years, we have studied the relationship between shape constancy and eye movement. Previc studied functional specialization in the upper visual field (UVF) and in lower visual field (LVF) in the human (F. H. Previc 1990). According to his study, the position in the early vision is neurophysiologically different with an object in the UVF and in the LVF. In the present study, we have investigated differences of shape constancy and eye movements related to objects in the UVF and the LVF.

3. APPARATUS

We used three reference objects: circle, square and square turned 45 deg. Each object was made of white acrylic board and suspended by a thin pole embedded in the central horizontal axis of the frontal plane. Objects are divided into upper and lower halves so as to be displayed in the UVF and the LVF, respectively. Acrylic boards can spin around the pole. For the standard objects, we made corresponding perspective shapes of the inclined objects by computer graphics on the CRT of a microcomputer. Vertical length of each object would vary as if it were inclined forward or backward in relation to the subjects.

4. METHODS

Psychophysical experiments were done using acrylic boards of three shapes (circle, square and lozenge: square turned 45 deg.) ; real objects and graphic patterns on CRT.

The perspectives of the shape, as displayed on the CRT as a standard stimulus was manipulated so as to appear to be inclined at angles in 10, 25, 35, 45, 55, 65, and 80 deg., respectively. Shapes composed of acrylic board and used as a comparison stimulus were inclined forward toward the subjects or backward away from subjects. Number of subjects is nine and each of them was mounted an eye mark camera. Eye movements of the subjects were also registered by an eye mark recorder.

5. ANALYSIS

We revised the Thouless index (R. H. Thouless 1931) as a degree of shape constancy. Revised Thouless index is defined by $Z = (\log S - \log P) / (\log W - \log P)$, where W is the length of the standard object from the center of rotational axis to the apex perpendicular to the axis, P is the length of the orthogonal projection of W to the frontal plane, and S is the length of the comparative object corresponding to W. By a statistical test, we analyzed the difference in shape constancy between the UVF and LVF and between for-

Table 1. Difference in shape constancy between directions of inclination of objects

Visual Field	Directions of Inclination: Forward vs. Backward
UVF	Statistically significant difference
LVF	No statistically significant difference

Table 2. Difference in shape constancy between the UVF and the LVF

Direction of Inclination	Visual Field: UVF vs. LVF
Forward	UVF < LVF
Backward	No statistically significant difference

ward and backward inclinations. Test of paired-difference by t -distribution were applied to the data. Eye movements of the subjects were also analyzed.

6. RESULTS

First, we examined the difference between orientations of inclination in the UVF and in the LVF. With the UVF, the tendency of shape constancy was greater in forward inclinations than in backward inclinations, with a difference at significance level of 2.5%. With the LVF, no statistical difference was observed between backward and forward inclination (Table 1).

Secondly, we examined the difference between visual fields in each orientation of inclination. In the case of forward inclination, no statistically significant difference was observed between the UVF and the LVF. In the case of backward inclination, neither was a statistical difference observed, however, the degree of shape constancy was larger in the LVF than in the UVF (Table 2).

Most of fixation points of eye movement in the UVF were coincident with the upper apexes of the boards and the graphic patterns. On the contrary no tendency was found in distributions of the fixation points.

7. CONCLUSION

In the present study, we found partial differences in shape constancy between the UVF and the LVF. This suggests the possibility of the functional specialization in the UVF and the LVF as well as the positional specialization. By the results of analysis of eye movement, it might be noted that a linear process in the UVF and a nonlinear process in the LVF are used.

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