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Perceptual Properties of Multi-Stably Perceptible 3-D Surfaces with Binocular Viewing: Orientation Dependency

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1. Introduction

We found the phenomena of multi-stable surface perception in which surface shape could be perceived several stable forms from an identical stereogram. We investigated the perceptual properties of these figures in relation to the orientation by using the simplest diamond shaped figure whose contour was identical with that of a polyhedron with four triangular surfaces and can be perceived as any of convex edge, concave edge or saddle shaped surface. The perception of multi-stable surface is easy to be changed by other visual conditions such as fixation depth, pre-perceived structure and so forth; then, it could be used effectively as a probe for investigating perceptual properties of visual system. Remarkable properties in these perceptions were that vertical edge line could be perceived easier than horizontal edge line and convex surface was easier than concave surfaces. Therefore, perception might be ambiguous when the test figure is possessing concave edge line vertically. It is inferred that at some certain orientations, our concave and convex perception rate of a diamond shaped figure could be the same. This orientation is called as balancing orientation of perceptually bistable stereogram. In

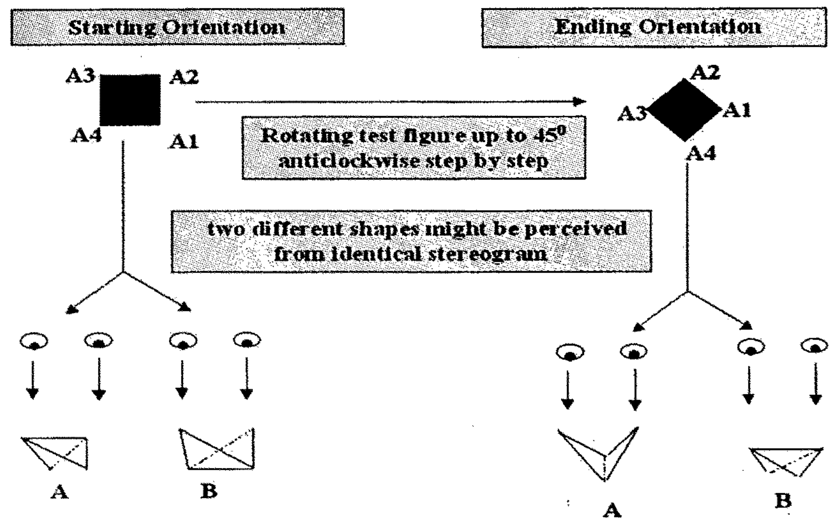

Fig. 1 The Experimental principle.

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order to get the balancing orientation, experiments were carried out according to the principle represented in Fig. 1

Here, the test figure is built as in Figs. 2 and 3. We might perceive either convex or concave from them. Normally, Fig. 2 is easy to be perceived as convex, on the contrary, Fig. 3 gives concave perception.

2. Experimental Procedure

The experiments were executed corresponding to the sequence shown in Fig. 4:

1) At first, a cross, which is playing as the fixation point, is shown at the center of the display screen. Subject is asked to gaze at the cross.

2) Then, the test figure is displayed at the same position on the display screen for 600 ms.

3) Subject is then asked to tell his perception of the test figure during the next 1000 ms with mouse click.

4) Thirdly, a flat disc is shown to diminish the aftereffect caused by the structure of previously displayed test figure.

5) With the perceptual data from the subject, the test figure is rotated step by step so that perception is approaching to the balancing orientation.

6) The above procedure is repeated until reaching the balancing orientation.

3. Experimental Results

Each subject has his own perceptual property; then the balancing orientations are found quite differently for individuals. Generally speaking, there are two kinds of subjects:

1) Have no balancing orientation: which means whatever the test figures are, the subject could only tell convex perception.

2) Have balancing orientations (Results are shown in Fig. 5)

Fig. 5 is showing the experimental results of two subjects who have balancing orientations. Here, Graph A shows the histories of how either subject reaches his own balancing orientation of 31.9 degree or 28.125 degree respectively. At each orientation, the test figure is shown for 20 times. If the total number of convex perception were larger than that of concave at the current orientation, test figure shown next step should be rotated towards

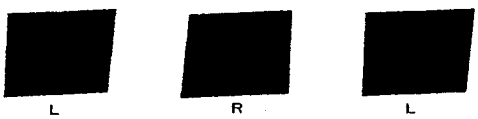

Fig. 2 Typical orientation giving convex perception (L: left eye view; R: right eye view).

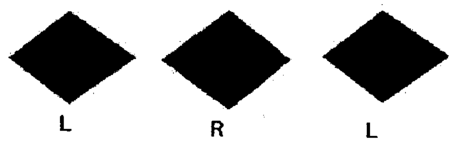

Fig. 3 Typical orientation giving convex perception (L: left eye view; R: right eye view).

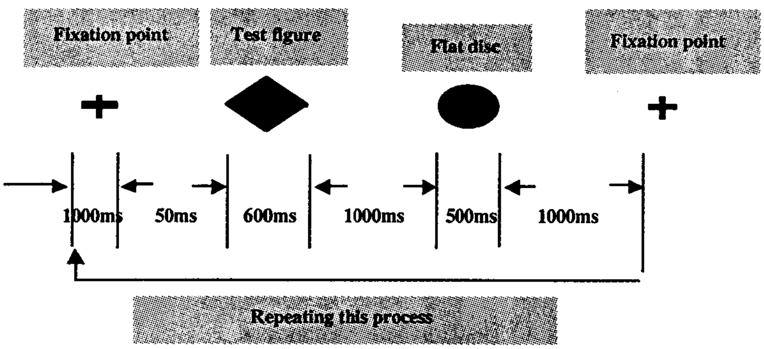

Fig. 4 Time sequence of the visual stimuli in the experiment.

to the orientation easy to be concave perceived, which is 45 degree in this experiment. On the reverse case, the test figure should be rotated towards 0 degree where easy to perceive convex. This procedure will be stopped when the perception rate of concave and convex is the same, or their difference is just one. Then this orientation is assumed to be the balancing orientation for the subject. Furthermore, we try to investigate the subject's perception just at his balancing orientation for another 20 times; we found that convex turns to be easily perceived for the subject even the same surface is shown at the balancing orientation repeatedly.

Graph B represents the perceived times of convex, concave and saddle surface of four kinds of test figures at the orientations of 0, 12.5, 37.5 and 45 degree. They are shown 10 times separately in random order. It describes how the subjects' perceptions of test figure vary from the orientation where convex is easily perceived to the orientation where concave is easily perceived. With graphs B, we can conclude that the balancing orientation for each subject is not only one orientation, but an arrange around 37.5 degree.

4. Perception with just One Hemisphere of Brain

We know that right and left view fields were projected to the left and right hemisphere of brain respectively, and our visual perception is executed by right and left brain hemispheres simultaneously. We expect to know whether our recognition is varied or not while we can just perceive with one hemisphere of brain (left or right hemisphere only). Fig. 6 represents some results we have got.

With what the graphs give, it is clearly that when subjects were required to tell his perceptions at one of his balancing orientations which was got from the previously done experiment, he inclined to tell convex than concave perception with normal conditions (Graph A).

Graph B represents the perceptions rates at the balancing orientation when the subject could just perceive the test figure with only one hemisphere of brain. As for the first subject, balancing orientation is kept with right hemisphere but convex perception becomes prominent for left hemisphere. However, it is not distinguishable that whether perception with just one hemisphere of brain is the same as with both hemispheres of brain

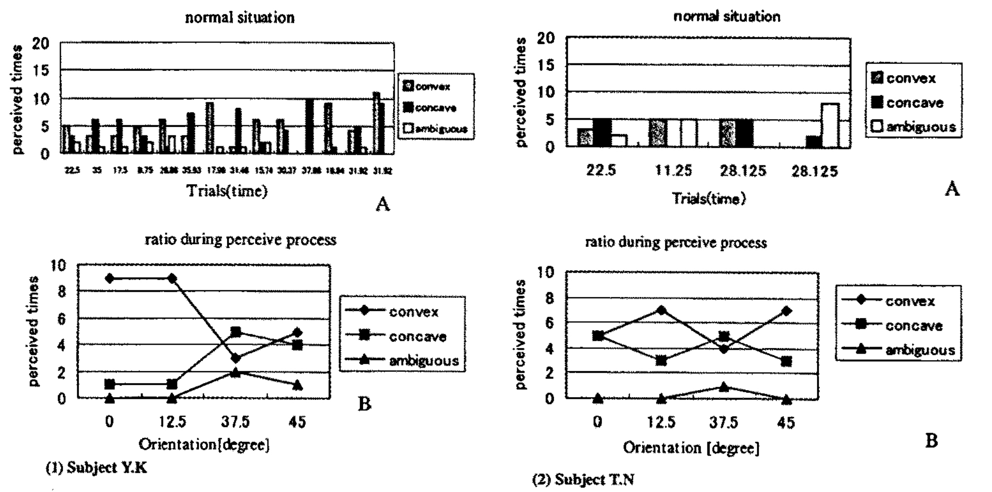

Fig. 5 Experimental Results of Two Typical Subjects.
A: Sequential balance searching procedure.
B: Random perception results.

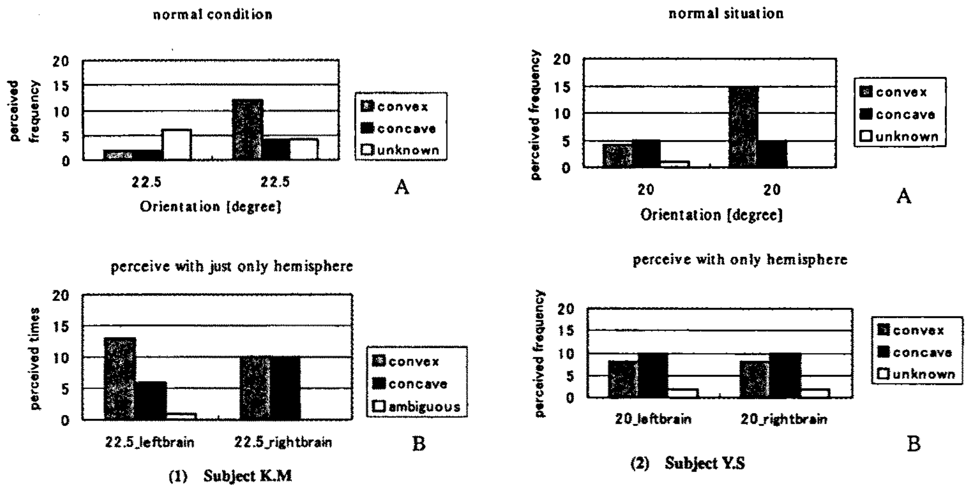

Fig. 6 Results at the Balancing Orientation.
A: Sequential balancing searching experiment with both hemispheres.
B: One hemisphere perception at the balancing orientation.

because for the second case, it is a little easier for the subject to report concave perception. Therefore, no distinguishable difference could be found comparing the results of one hemisphere with both hemispheres at least in the present experiment.

5. Summary

Having got the balancing orientation of each subject, we can use this as a probe to inspect such as the effects of ahead heard voice stimuli or tactile stimuli on our vision system and so on.

In addition, we need to investigate more in detail about whether the results would be exactly the same while the subject could just perceive the test figure with only one hemisphere of brain comparing to the case while he can perceive with both hemispheres of brain.

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