JSL, Volume 1 (2005), 107–125

Simple Figures and Perceptions in Depth

Kazuo OHYA

In experimental psychology, observations are the important base of sound investigations. For observations, adequate stimuli are necessary. I want to collect and publish some useful simple stimuli for observations. This paper contains elementary simple figures related with 3D perception.

I. Purpose of this paper[1]

In experimental psychology, observations are the important base of sound investigations. For observations, adequate stimuli are necessary. But even simplest stimuli need some troublesome works for their making. So sometimes basic observations are neglected. This tendency is undesirable for researches. And these observations facilitate general understanding of scientific psychology. I want to collect and publish some useful simple stimuli for observations. This paper contains elementary simple figures in that collection.[2]

II. What is the problem?

In this paper I include simple figures related with the problem of depth perception. Figure 1 indicates some points.

In (a) we see a white rectangle with black contour. Certainly some observers see different things. Human perception shows many individual differences. In my later explanation, I show only a few ways of perception, of many ofservers, I hope. The contour and inner part lie on the same plane.

But when the contour become thick like (b) we see deferent tings. Sometimes we see a black frame with a rectangular hole. Sometimes we see a white rectangle on a black rectangle. What is the reason of these different perceptions? For these perception, is the thickness of contour important? Or is it important that the surrounding black part of the rectangle comes to get the property of some 'object'?

In (c) there is a white trapezoid with black contour. But sometimes we see a slant rectangle in depth.

In (d) probably we see a slant black frame.

If we add another component in the scene, what different perceptions appear? In Figure 2 we add a white circle. At the top row, in the black frame figure the hole is difficult to perceive. At the middle row, sometimes we feel strange sensations. When we see a slant

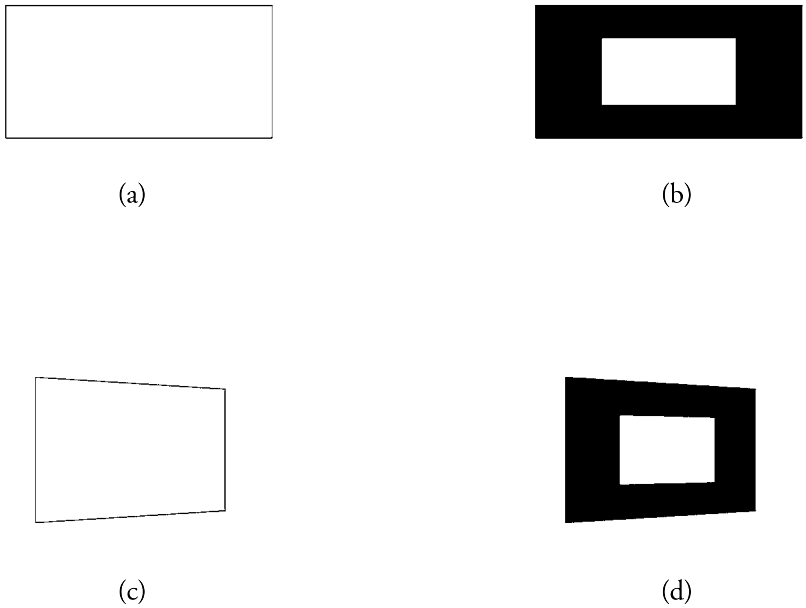


Figure 1. These simple figures indicate some points in depth perception.

object, the perception of circle does not fit the perception of rectangle. In the figures of the bottom row, we replaced the circle with a ellipse of adequate proportion. With this object, the rectangle and ellipse form a plane.

When the circle is painted black (Figure 3), sometimes the black circle appear separate from the white background. The black frame and black circle can form a plane. These simple figures can make such different perceptions in depth. There are many experimental explorations in these phenomena. There are many good references. Especially Howard and Rogers (2002) is exhaustive and includes many interesting figures. From the results of such investigations binocular disparity is known to play a part in the human depth perception. So in the rest of this paper I included simple figures with disparity.

III. How we can see depth from 2D figures

To observe these figures is not an ordinary experience. So untrained observers often needs some training to gain 3D perception seeing these figures. Here I indicate some points useful for the untrained observer to see depth.

The elementary knowledge of binocular disparity can fasciliate the depth perception. In Figure 4, I show general schemata. Our eyes are separate some distance from each other. When we see objects in different planes, relations of their retinal images differ in both eyes (Figure 4a). We can produce these relations on our retina from the pair of stimuli in the

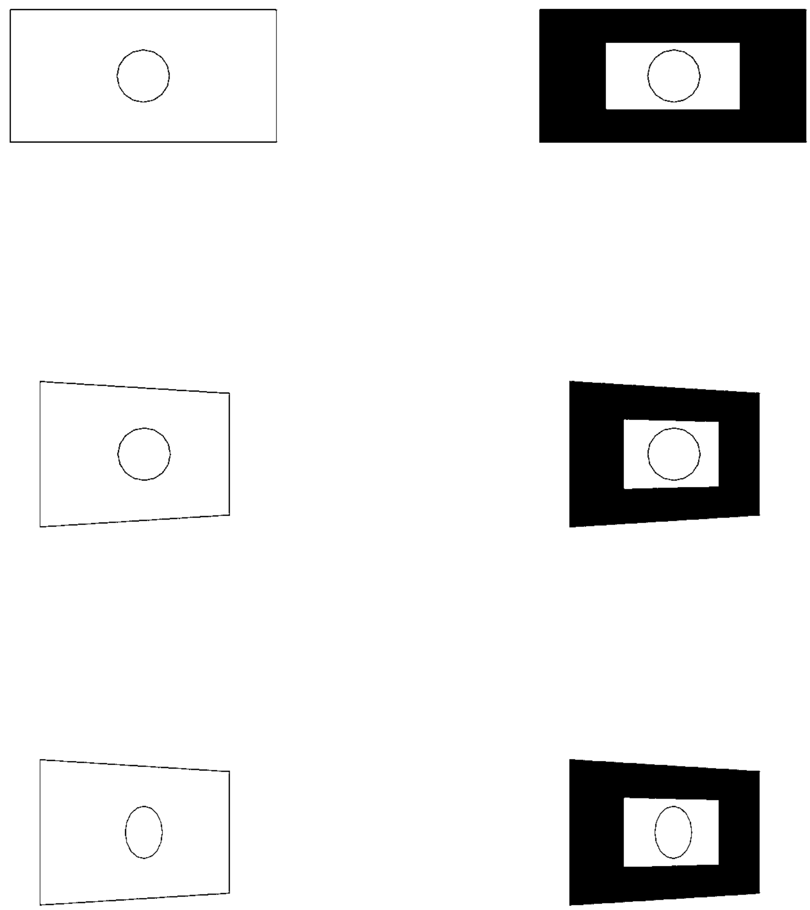


Figure 2. With another object, different perceptions appear.

same plane (Figure 4b).

In Figure 4b informations from the left figure enter only the left eye. Informations from the right figure enter the right eye. When we use the stereoscope, such condition comes true. As a easier method, by means of some partition we can limit our view so that one eye can see only one figure.

Without help of such devices it may be difficult or impossible to make each eye take into informations from the one figure only. But human perception mechanism can compare and evaluate informations from both eyes. So if in different eye, informations from different eye dominate, we can see depth.

We can select informations to some extent. So try to select the informations of different figure from informations from different eye.

In Figure 4b, informations from each figure pass parallel. Some people can take

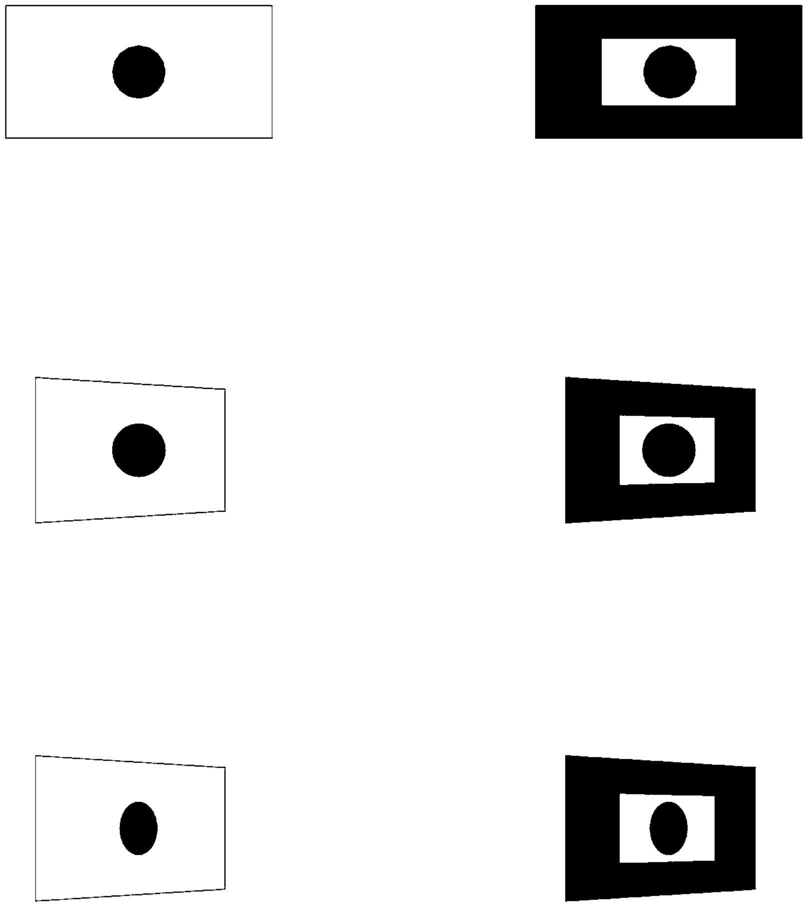
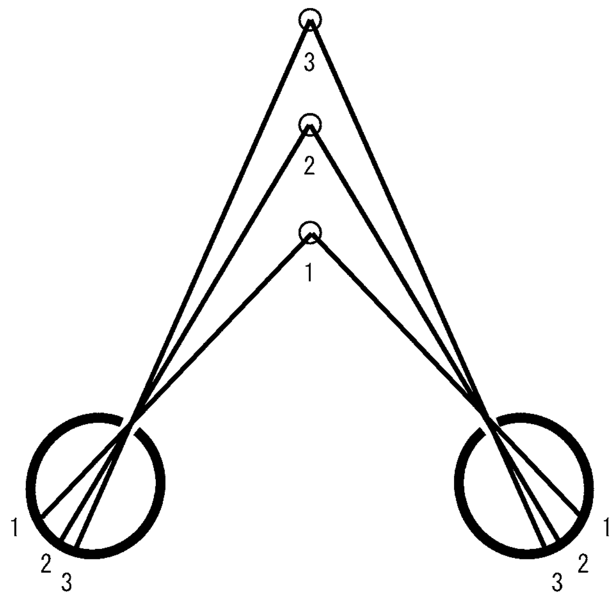


Figure 3. When the circle is painted black are there differences?

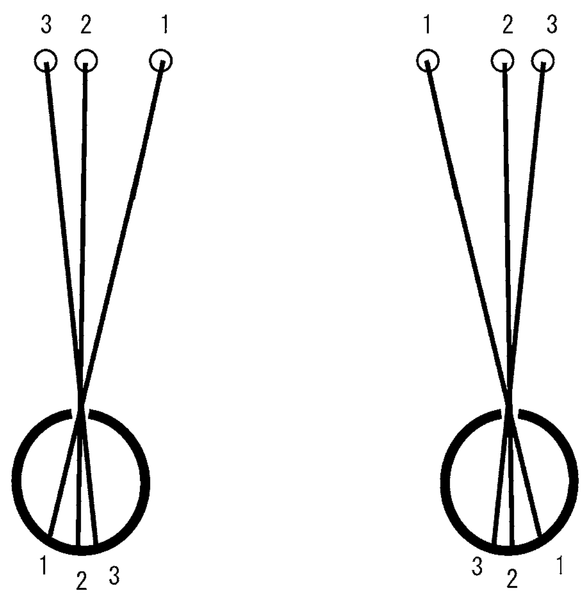
informations of the left figure with the right eye, of the right figure with the left eye. With this crossing method they can see depth. The perceptions of relative depth of objects are in reverse order in each method. In later paper we consider from the view of observation with the parallel method.

First try to make one object fuse into one image. For that purpose adjust observation conditions, e.g., observation distance and viewing direction.

In figures with disparity, there are horizontal bars in the left figure, vertical bars in the right figure (e.g., Figure 5). Try to perceive all four bars. When you make judgements, turn your attention to the crossing point of the assumed horizontal line connecting horizontal bars and the assumed vertical line between vertical bars.



(a) Stimuli lie on different planes.



(b) Stimuli lie on the same plane.

Figure 4. Simple diagrams explain how we see depth from 2D stimuli.

IV. The description of figures with disparity

In these figures I included three paires of stimuli. In every middle row pair there is no disparity between the left figure and right figure. In the top and bottom pair there is disparity. For example in Figure 5, if binocular disparity has a dominant effect on the depth perception, in the top pair the circle is seen in front of the rectangle. In the middle pair a circle lies in the same plane of a rectangle. In the bottom pair a circle is seen at the back of a rectangle. Some observers see rectangular frame and directly a circle. Some observers see a transparent rectangle and a circle at the back of it.

As explained earlier, these depth perceptions appear in the parallel observation. In the crossing observation, a circle is seen in front of a rectangle in the bottom pair. In the top pair a circle is seen at the back of a rectangle.

Comparing perceptions from this Figure with Figure 2, we can get hints on the mechanism of depth perception.

In Figure 6 I made the contour thicker.

In Figure 7 a rectangle and a filled circle are exposed.

In Figure 8 a black rectangular frame and a filled circle are exposed.

In next figures we consider the factor of form and binocular disparity.

In Figure 9 a trapezoid and a circle are exposed.

In Figure 10 a trapezoid frame and a circle are exposed.

In Figure 11 a trapezoid and a filled circle are exposed.

In Figure 12 a trapezoid frame and a filled circle are exposed.

If the rectangle and circle are in the same plane and slanted simultaneously, the retinal image of circle is deformed. I estimated this effect and in next figures exposed such elipse. Do observers see more easely a slanted rectangle and circle?

In Figure 13 a trapezoid and a ellipse are exposed.

In Figure 14 a trapezoid frame and a ellipse are exposed.

In Figure 15 a trapezoid and a filled ellipse are exposed.

In Figure 16 a trapezoid frame and a filled elliose are exposed.

In human perceptions there are many individual differences. So we should observe without prejudice repeatedly.

V. Summary

In experimental psychology, observations are the important base of sound investigations. For observations, adequate stimuli are necessary. But even simplest stimuli need some troublesome works for their making. So sometimes basic observations are neglected. This tendency is undesirable for researches. And these observations facilitate general understanding of scientific psychology. I want to collect and publish some useful simple stimuli for observations. This paper contains elementary simple figures in that collection.

As the target problem, I selected relations between depth perception and binocular

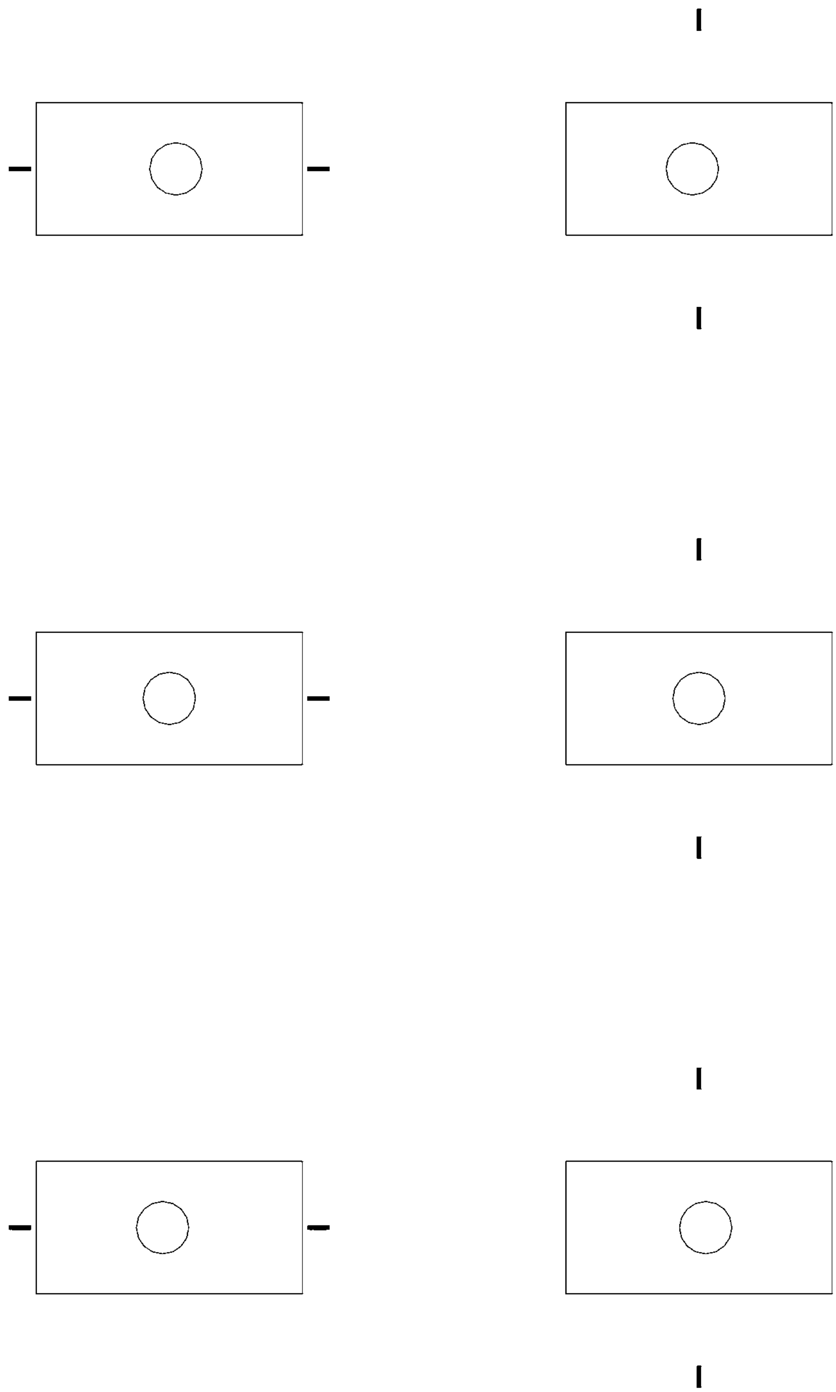


Figure 5. The rectangle and circle with binocular disparity.

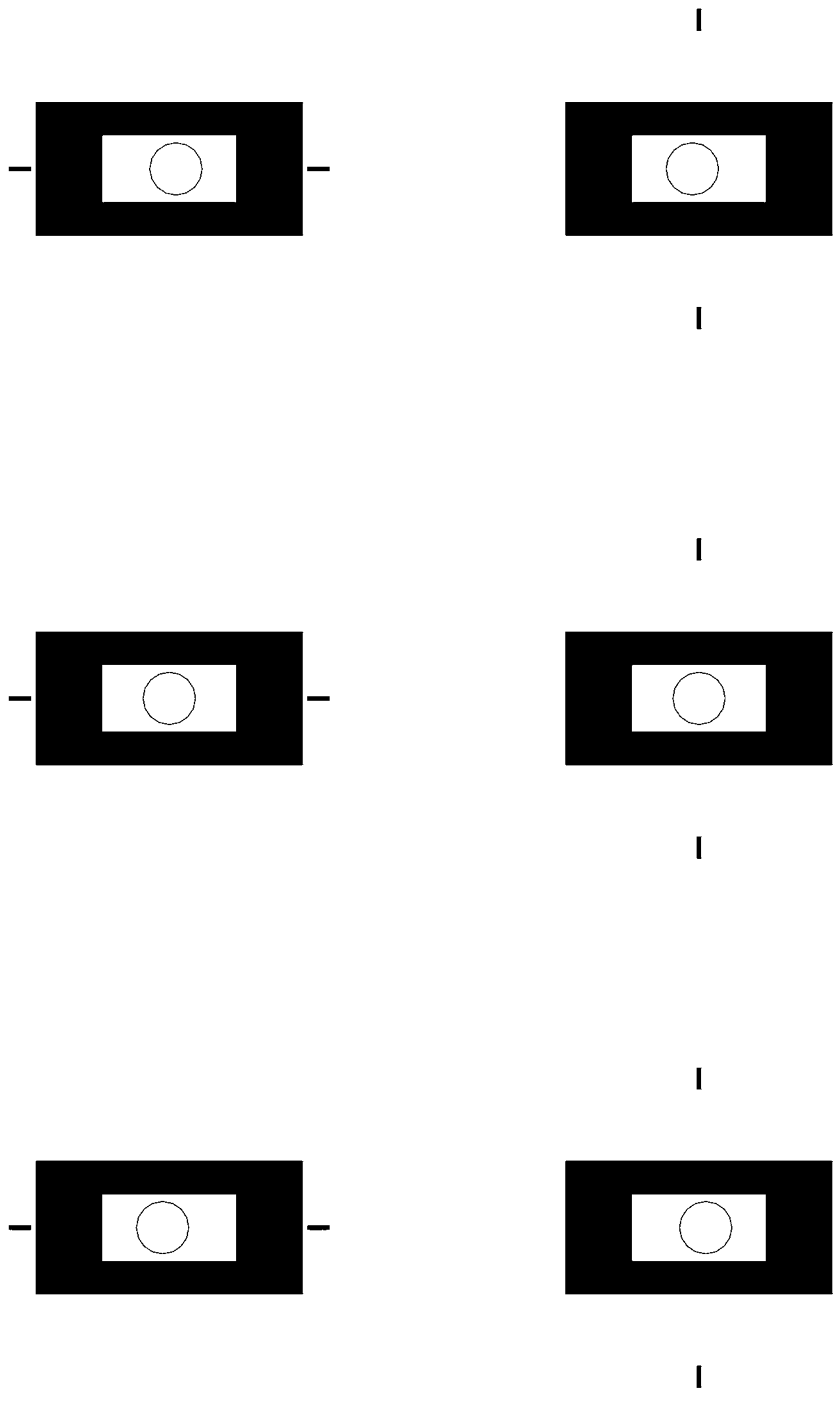


Figure 6. The frame and circle with binocular disparity.

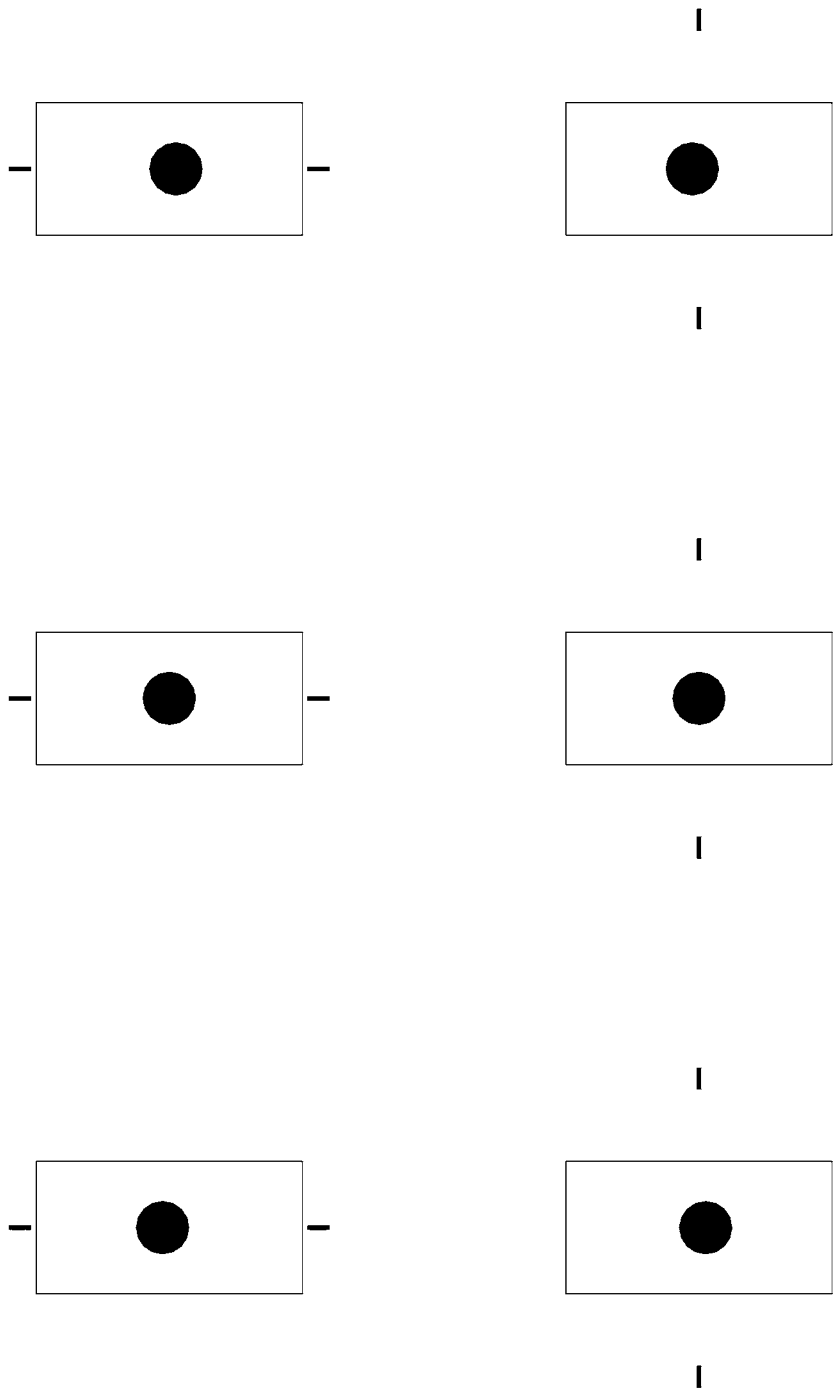


Figure 7. The rectangle and filled circle with binocular disparity.

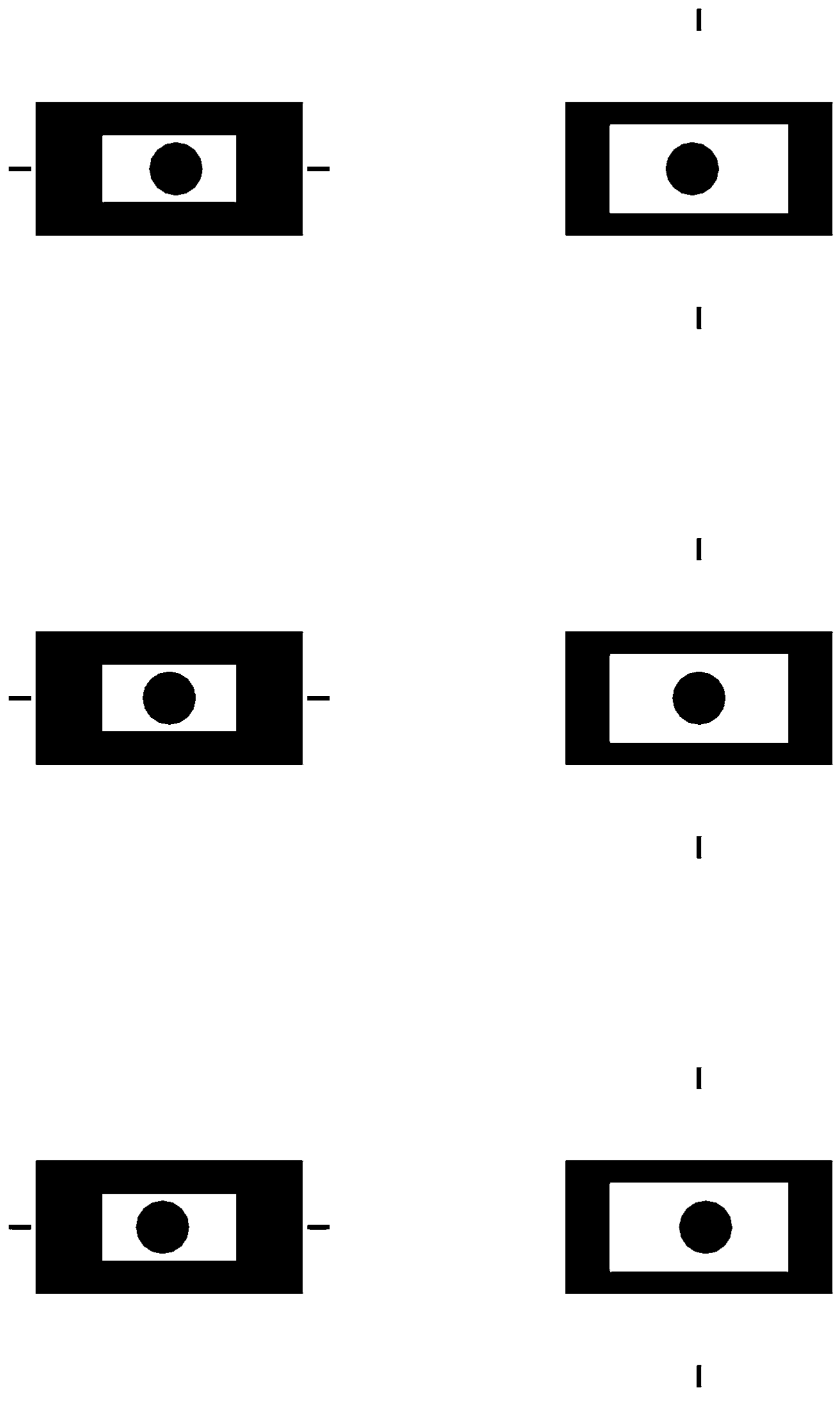


Figure 8. The frame and filled circle with binocular disparity.

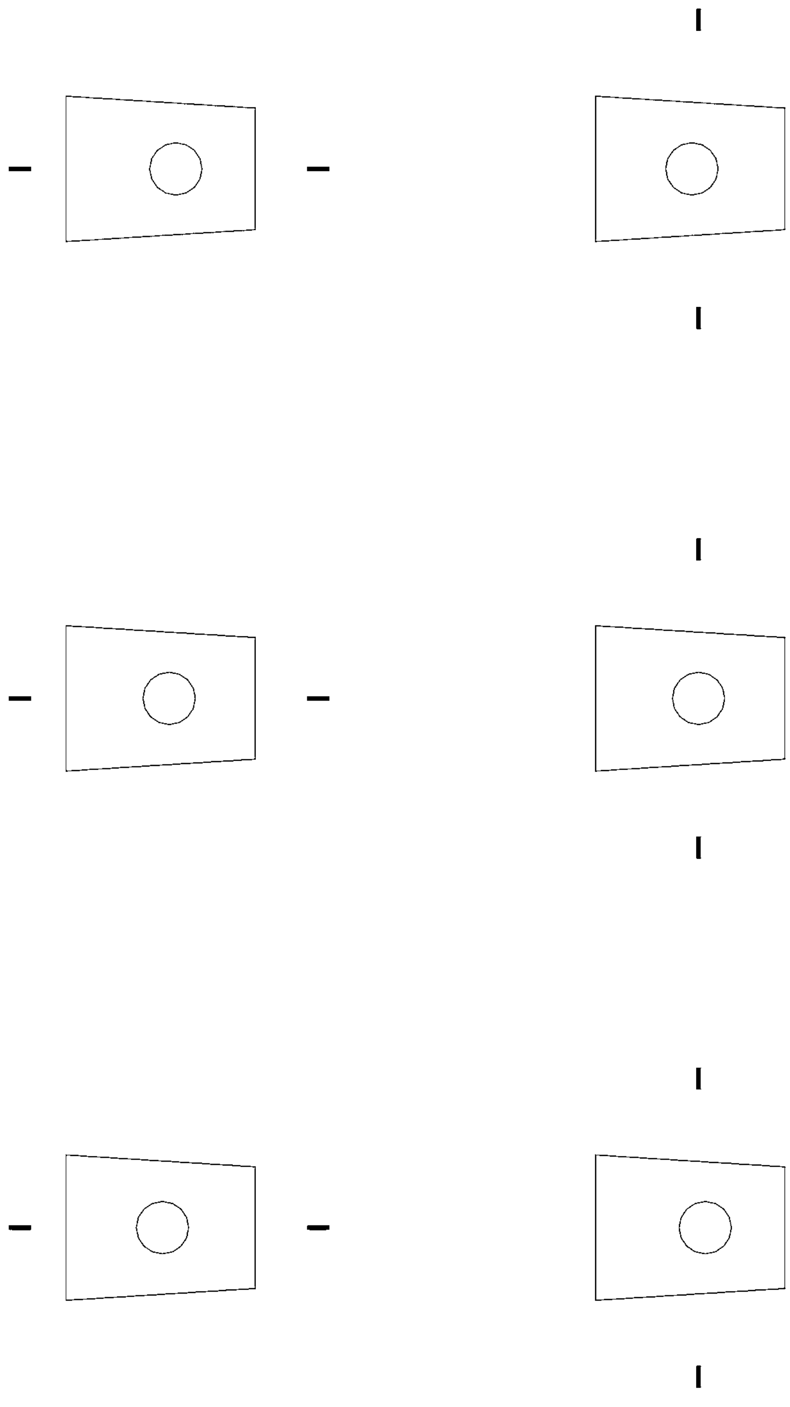


Figure 9. The trapezoid and circle with binocular disparity.

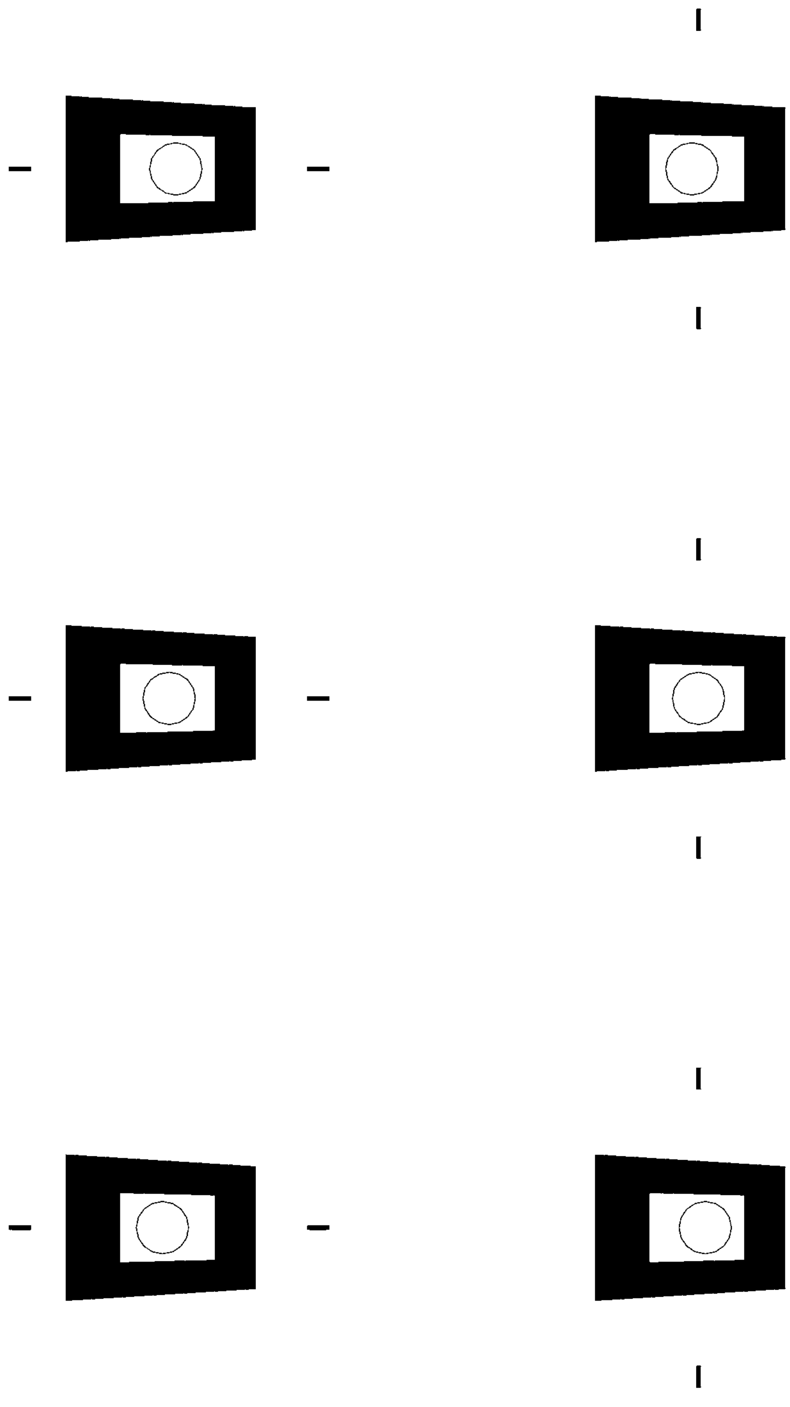


Figure 10. The trapezoid frame and circle with binocular disparity.

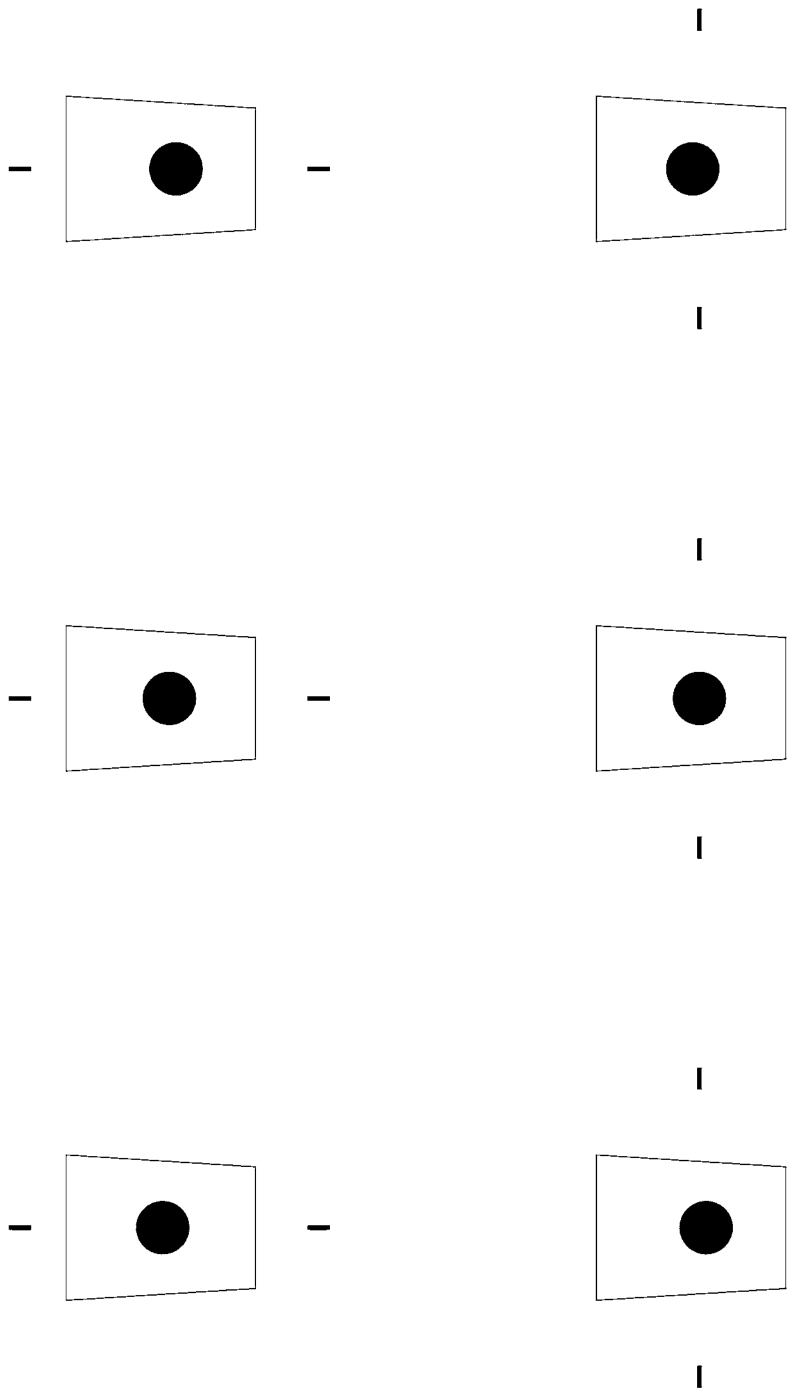


Figure 11. The trapezoid and filled circle with binocular disparity.

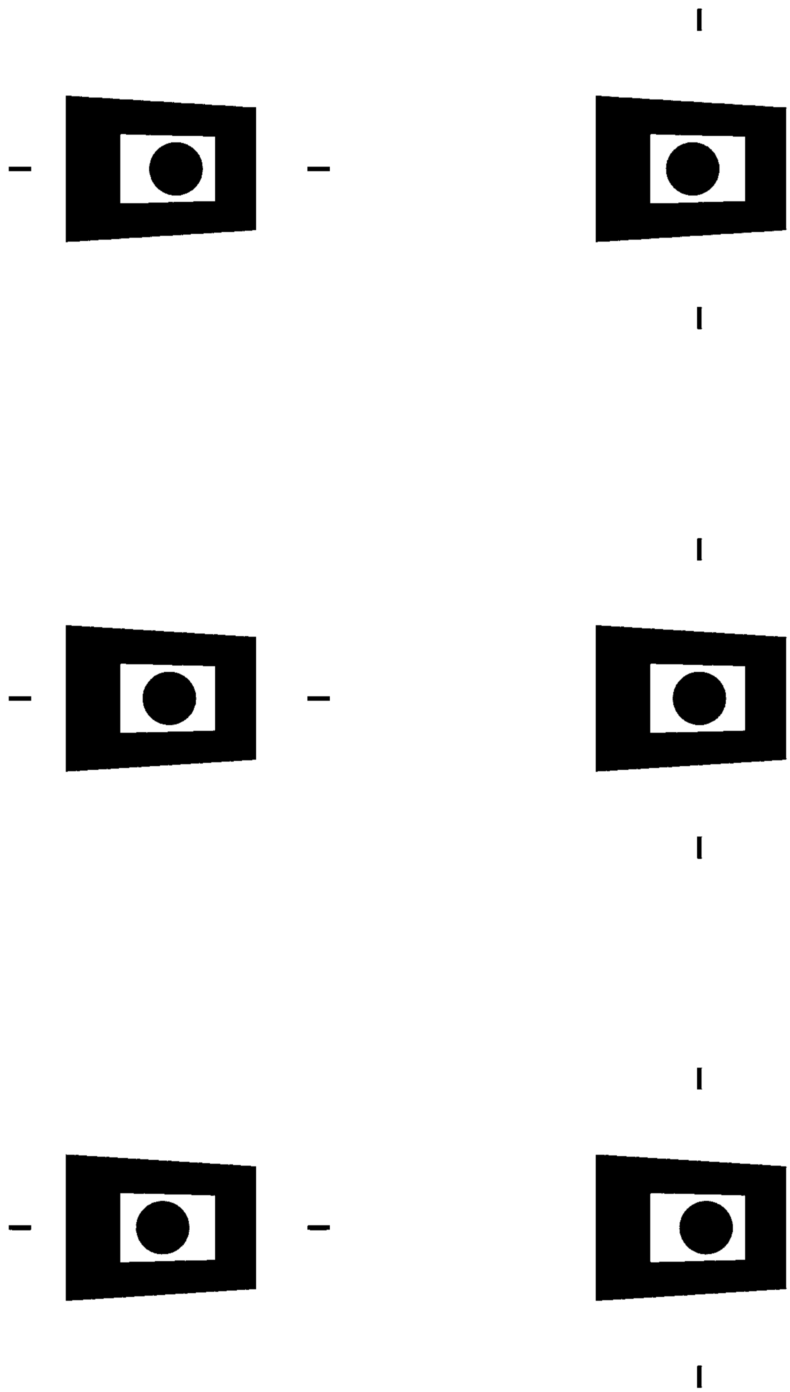


Figure 12. The trapezoid frame and filled circle with binocular disparity.

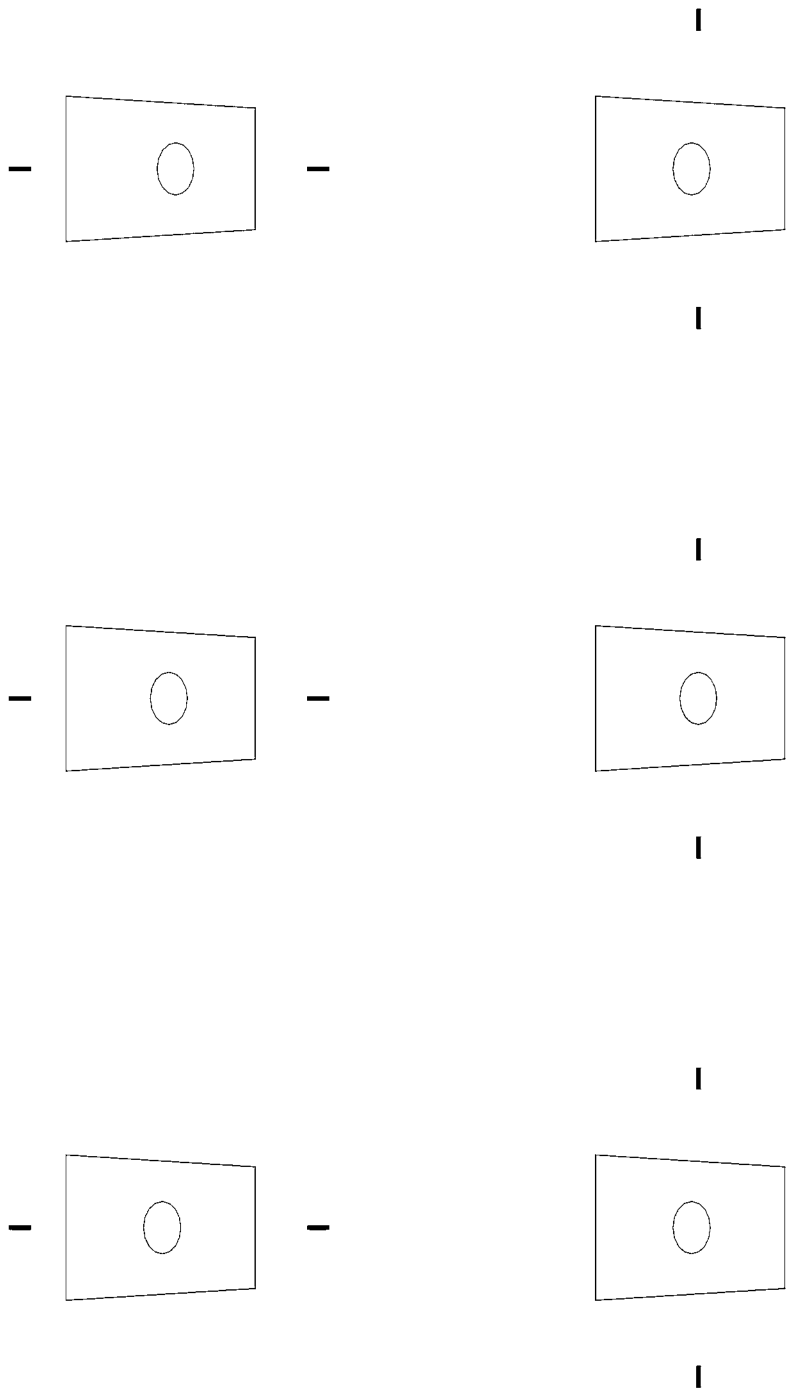


Figure 13. The trapezoid and slant circle with binocular disparity.

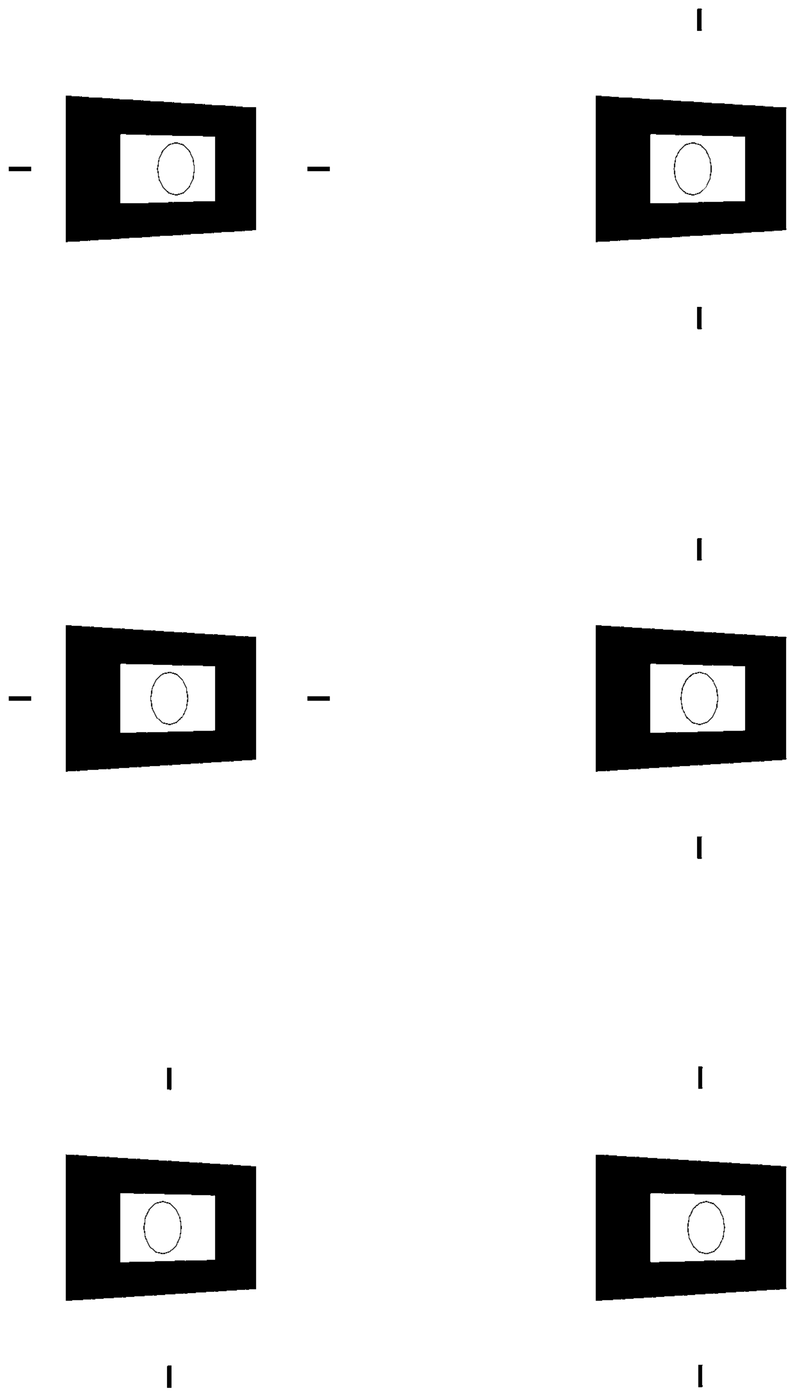


Figure 14. The trapezoid frame and slant circle with binocular disparity.

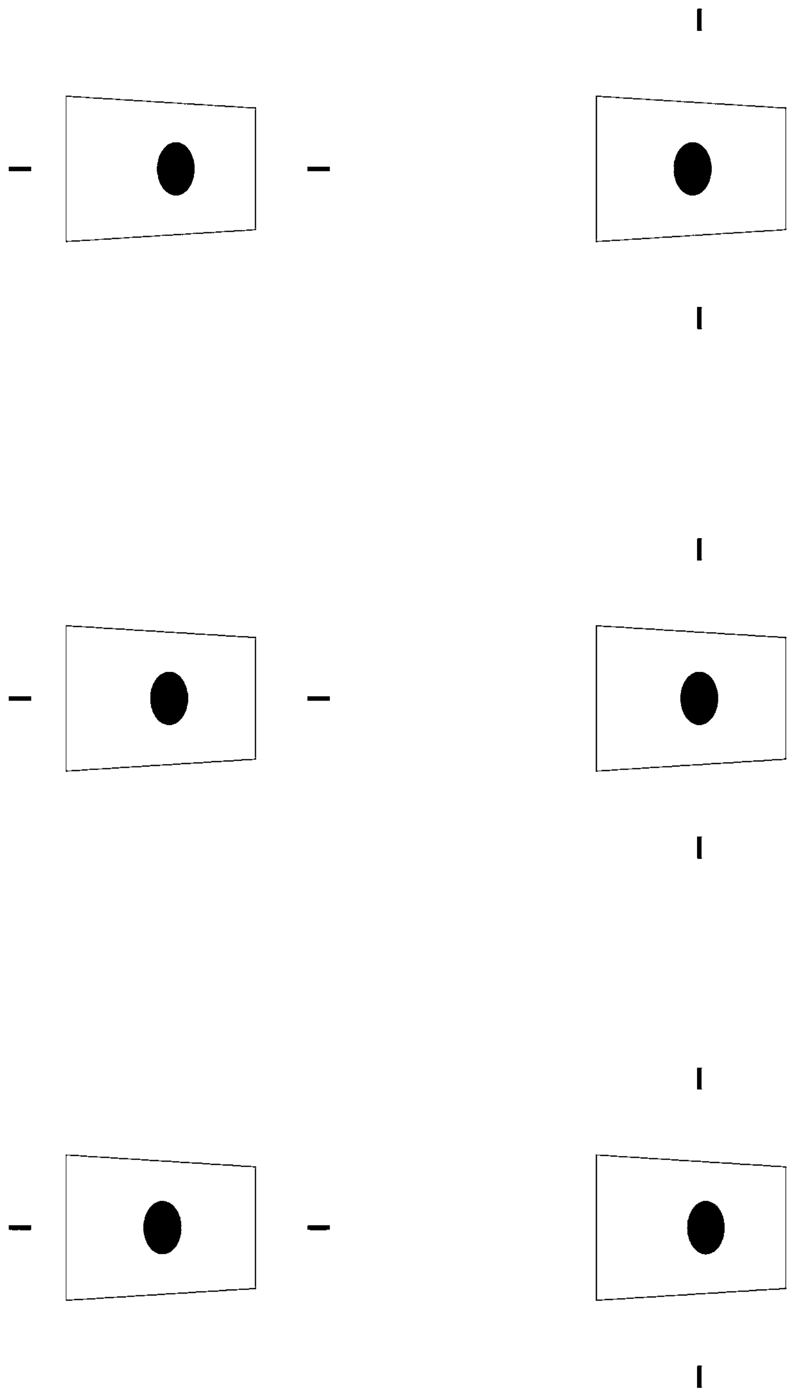


Figure 15. The trapezoid and slant filled circle with binocular disparity.

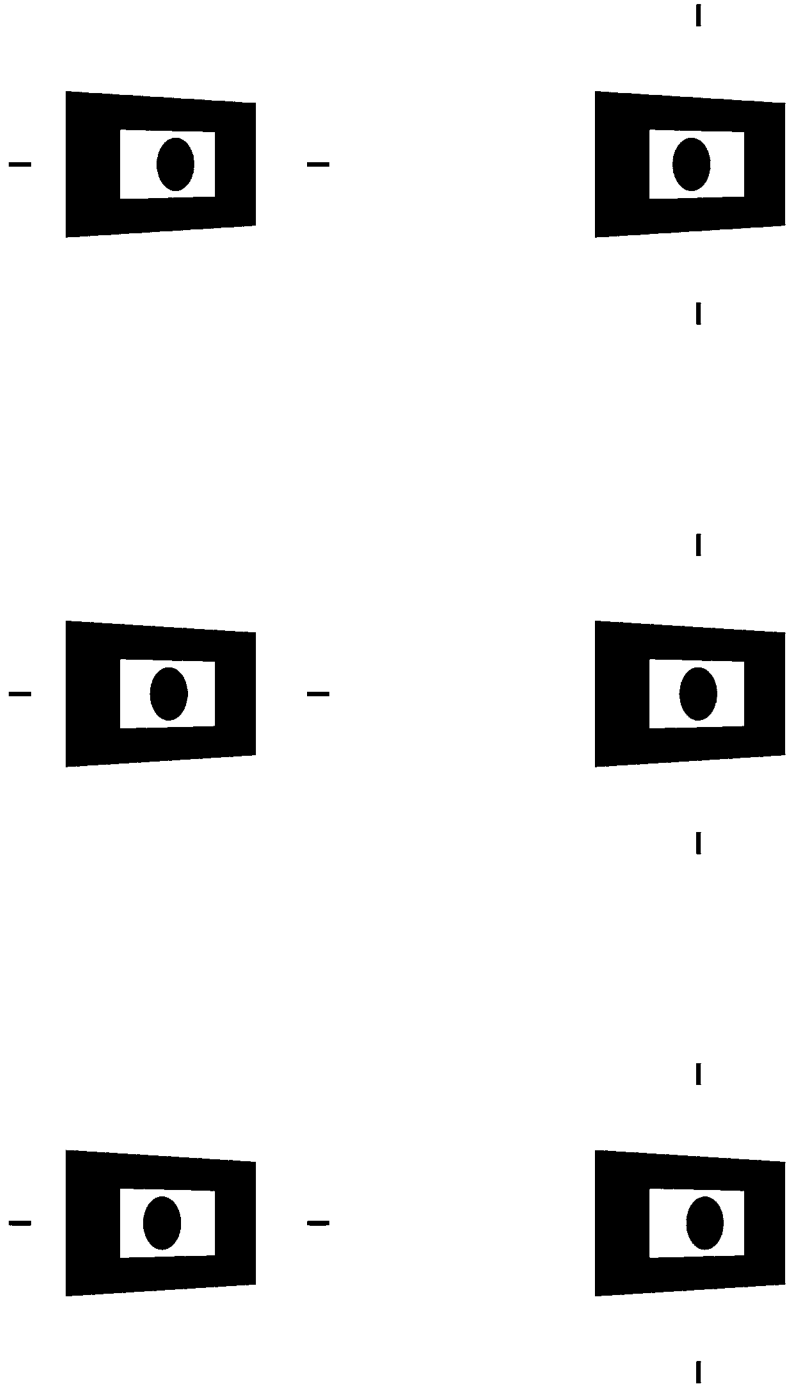


Figure 16. The trapezoid frame and slant filled circle with binocular disparity.

disparity. In this paper figures are included which may be good for gaining hints in next problems.

In depth perception, what are the effects of these factors, thickness of contour versus binocular disparity deformation versus binocular disparity?

Notes

1 I thank members of Kanizsa illusion research group of Nagoya University, Shinya Takahashi, Keiko Arakawa, Yuko Ishisaka, for their fruitful suggestions.
2 I utilized computer programs, Corel Draw Graphics Suite 12 (© Corel Corporation) and Shade 7 Standard (© e-frontier, Inc.).

Reference

Howard, I. P., Rogers, B. J. 2002 *Seeing in Depth II Depth Perception*. Thornhill, I. Porteus.