How To Make Triply Ambiguous Objects

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This note is to present the method for constructing the "Triply Ambiguous Object" that won the first prize at the Best Illusion of the Year Contest 2018.

1. Background Properties of Pictures

A 3D object bounded by planar faces that are connected at 90 degrees is called a *rectangular object*. The rectangular object contains only three groups of mutually parallel faces and three groups of mutually parallel edges. As the result of this, an orthographically projected picture of a rectangular object also contains only three groups of parallel lines. The next picture is an example, where the three groups of lines are mutually in 120-degree angles.
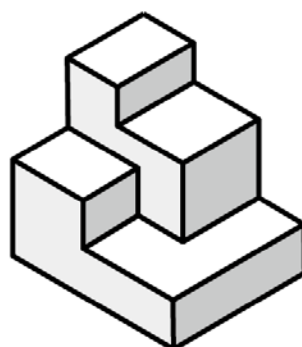

There are three postures of the picture, in which one group of parallel lines are vertical, as shown in the next figure.
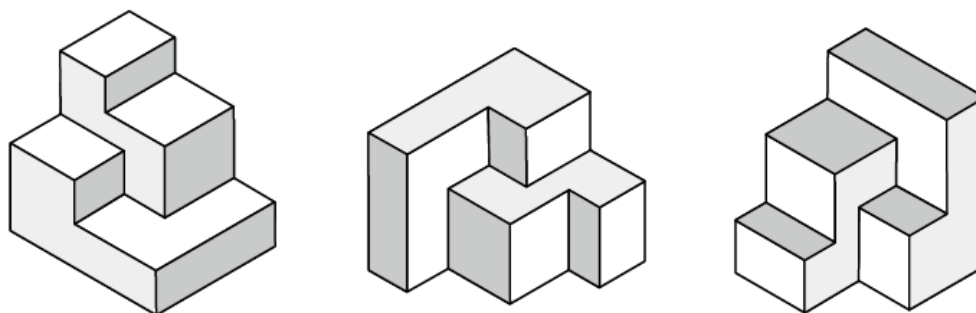
It may not be easy to recognize that these three pictures are obtained by rotating the same picture. This implies that it may not be easy to recognize that they represent different postures of the same object.

Next let us see these pictures from below in a slanted direction. Then they change to the following. Now it becomes much more difficult to recognize that they come from the same picture.
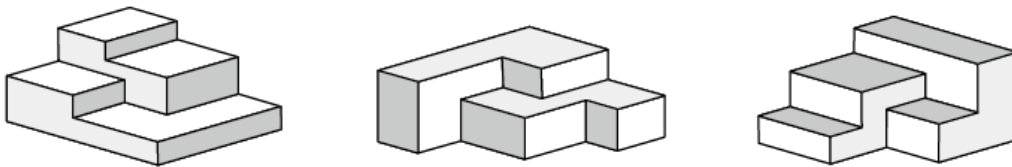
These three pictures are compressed in the vertical direction. Consequently, if we consider them as the orthographically projected pictures, then they represent different objects instead of representing different postures of the same object. These properties of the picture of a rectangular object can be used to construct the triply ambiguous object.
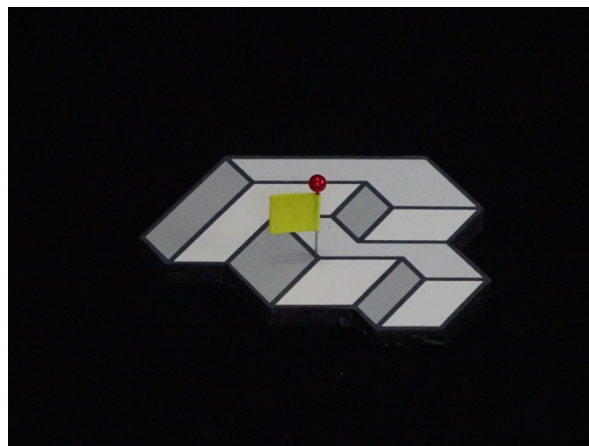
2. Construction Method

The triply ambiguous object can be constructed by the following steps.

Step 1.

Draw a picture of a rectangular object, and put it on a horizontal plane.

Step 2.

Place a vertical pin with a flag at a convex vertex. The next image represents the picture with the pin.

Let us call the resulting object an *artwork*.

Step 3.

See this artwork in slanted direction in such a way that one group of parallel lines are vertical. Then we perceive three different rectangular objects. We can see the three appearances simultaneously by placing two vertical mirrors behind the artwork.
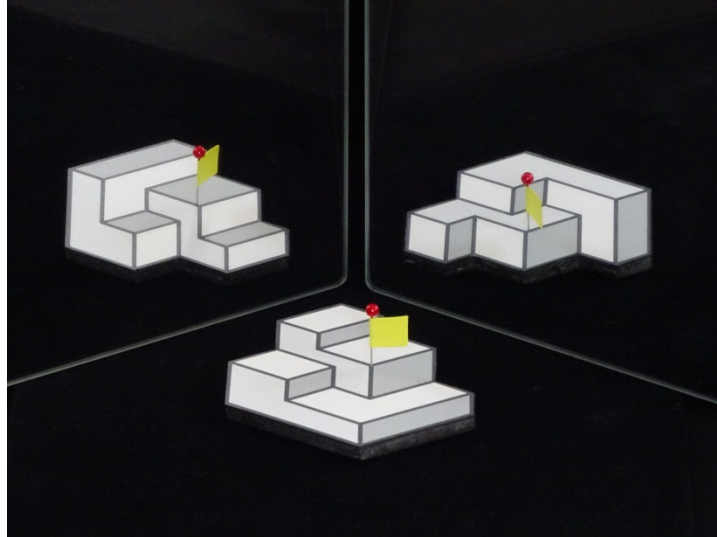
3. Why Does the Illusion Occur?

The artwork is just a 2D picture placed on a horizontal plane decorated by a vertical pin with a flag, but can generate perception of three different objects. Why does this happen? I understand this illusion is the result of the following factors

Factor 1.   This is a video captured by a camera.

If we see the artwork directly, we cannot enjoy the illusion. We have two eyes, and can detect the distance to the object surface by binocular stereo, and consequently we perceive a horizontally oriented picture. The illusion occurs only when we see the artwork by a single eye. Taking video by a camera is equivalent to seeing the artwork by a single eye, and hence we can enjoy the illusion when we see the video by two eyes.

Factor 2.   Our brains prefer rectangular objects.

The retinal image is 2D, and hence does not contain the depth information. Therefore, there are infinitely many possibilities of 3D structures whose projections match the 2D image. Among them, our brains usually choose the interpretation containing many rectangles. In particular, if the picture contains only three groups of

parallel lines, our brains interpret it as a rectangular object. As a result, we perceive a 3D object instead of a 2D picture.

Factor 3. The pin with a flag represents the direction of gravity.

When we see the artwork in a slanted direction, we feel that we are seeing something in the 3D space instead of just seeing a picture facing toward ourselves. In this situation, we are conscious about the direction of the gravity, which is emphasized by the pin standing vertically.

I understand these factors together create the illusion of triple ambiguity.