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Last but not least

The sawtooth illusion

It is well known that a given 2-D image could be the projection of countless object configurations in the world, each of which is consistent with that image. In order to correctly interpret the inherently ambiguous image, the visual system must make assumptions about likely configurations of objects in the world (eg Knill and Richards 1996). Many authors have noted that one such assumption or 'prior' concerns the existence of a ground plane (eg Albert and Tse 2000; Gibson 1979; Gregory 1970; Hoffman 1983; Richards et al 1996; Rock 1983; Rock et al 1978; Tse 1998). Here, I would like to report a simple but compelling illusion that makes obvious the existence of the 'ground plane assumption' by the visual system.

I first noticed this illusion on the back of a wooden watchcase. Unfortunately, I have been unable to find the craftsperson who designed it. After ECVP '99 I noticed a weaker version of this illusion on the inlaid marble floors of the Duomo in Siena, placing the origins of the illusion back to at least the late medieval period. To my knowledge, however, it has never been reported in the scientific literature. I have redrawn the illusion in figure 1 to emphasise its effect.

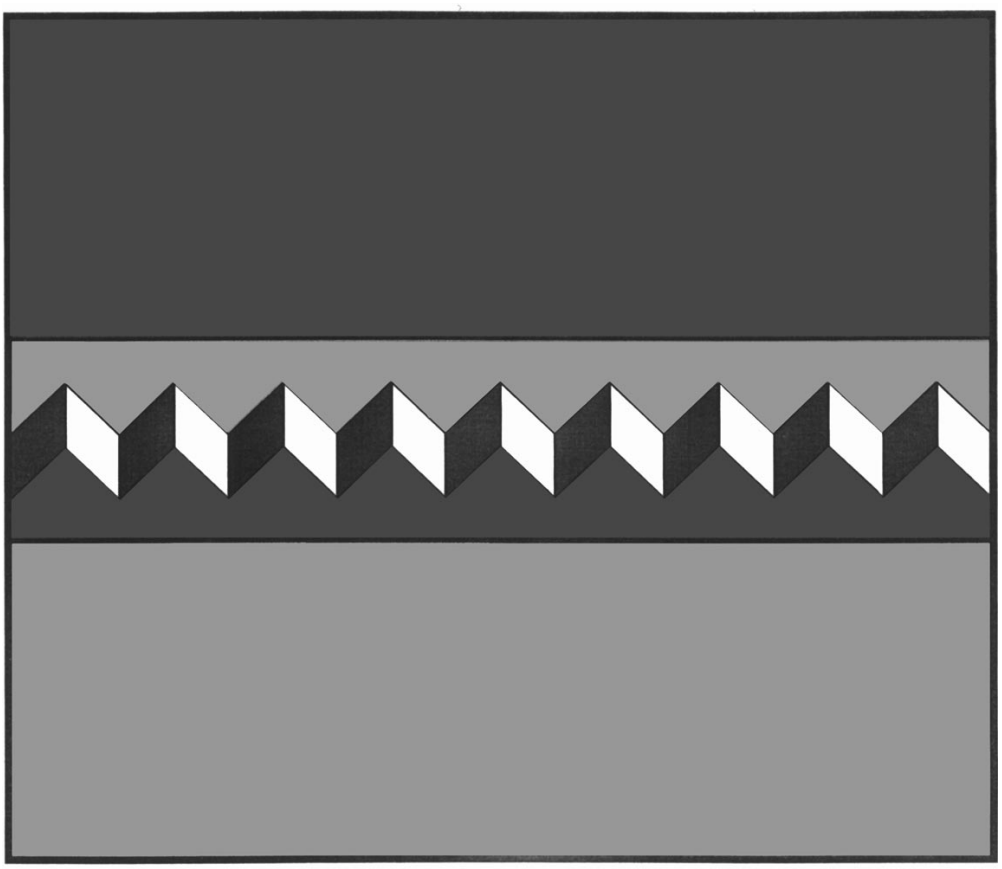

Figure 1

Figure 1 is open to at least two interpretations. Under one interpretation, 'pyramids' appear to be oriented vertically with respect to a ground plane. Either this ground plane is flat, and one is situated above the ground plane and looking down on it, so that the line of sight to the horizon makes about a 30° angle with respect to the ground plane, or one is near the ground plane and the ground plane has about a 30° slant, so that the horizon is at a higher elevation than the foreground. Under the other interpretation, the 'teeth' of a saw face the viewer and lie flush with the ground plane. Again it is ambiguous whether the ground plane is slanted or one is viewing the ground plane from above. If one turns figure 1 upside down, what was sky now becomes ground plane and vice versa. Besides making apparent the existence of a ground plane assumption, this illusion also makes apparent the existence of a prior on interpreting ambiguous objects as either resting on a ground plane or protruding from the ground plane at a right angle (cf Richards et al 1996).

If one rotates figure 1 by 90°, the illusion of a ground plane disappears. Instead, the saw's teeth appear to be attached to a frontoparallel wall. Now the saw's teeth are not oriented at 0° or 90° with respect to their supporting surface, but rather are slanted with respect to it, again at about a slant of 30° away from the wall (or 60° away from the line of sight). Cues to slant in the angle relationships of the saw's teeth that were previously used to infer the orientation of the ground plane are now used to attribute slant to the row of saw teeth itself. Thus, local cues to surface orientation are ambiguous. They convey information about the slant of a surface only relative to the inferred orientations of other, more global surfaces. In particular, the inferred slant of the supporting or underlying surface, such as a ground plane or wall, seems to dominate the perceived orientations of supported surfaces.

Rock (1973) showed that perceived form depends more on the orientation of a stimulus in world coordinates than it does on orientation in retinal coordinates. The same applies for this illusion because, if one rotates one's head 90° and views figure 1, the retinal image will be the same as if one rotated figure 1 90° and viewed it from an upright stance. However, one still tends to see either a ground plane with protruding pyramids or a saw's teeth flush with the ground plane. Conversely, if one rotates figure 1 90° and then views it with a 90°-rotated head, so that the image projection is the same as when figure 1 is viewed normally, the supporting surface still tends to look like a frontoparallel wall. Thus, the ground plane assumption appears to operate, by default, in world rather than image coordinates.

In conclusion, this simple illusion of unknown origin makes explicit the tendency of the visual system to interpret images in terms of objects lying on a ground plane or other supporting surface wherever ambiguities in the image permit such an interpretation. When the supporting surface is taken to be a ground plane rather than a wall, there may be a prior on objects oriented vertically or horizontally with respect to that ground plane. This may be because these are the two orientations that can most stably resist the force of gravity or because these are the most common orientations of objects in our experience. Last, the ground plane assumption appears to operate in world rather than image coordinates.

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