



The Ames room and the misunderstood versions and depictions

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The Ames room and the misunderstood versions and depictions

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Abstract

The Ames room illusion is one of the best-known geometrical illusions but its geometrical properties are often misunderstood. This study discusses the differences in the geometrical properties between the original Ames room and what have been often referred to as “Ames rooms” in recent studies.

Main

The Ames room usually refers to the “monocular distorted room no. 1” (Fig. 1a) or the “full size monocular distorted room” in Ittelson (1952). The Ames room is a non-rectangular hexahedron that is designed so that a retinal image of its interior space (room), when seen from a specific viewpoint, becomes identical to the retinal image of a rectangular illusory room (Day, 1993; Ittelson, 1952, see https://www.youtube.com/watch?v=W_5wpPxCcyw&t=1254s). Unfortunately, the geometrical properties of the Ames room are often misunderstood.

The Ames room consists of six planar faces. One wall is a trapezoid and has a viewing hole through which an observer can see the interior of the room.¹ This wall is referred to as the viewing wall in this study. The hole is closer to the shorter of the two side edges of the viewing wall. The wall facing to the observer is another trapezoid and is slanted relative to the viewing wall. The two side walls are rectangles of different sizes. The floor and the ceiling are also trapezoids and they are not horizontal. The floor often has a distorted-grid pattern composed of line-segments (Figure 1e). The retinal image of the Ames room seen through the hole is identical to the retinal image of a rectangular illusory room seen from a hole at the center of one of its walls. The distorted-grid pattern on the floor of the Ames room appears as a rectangular-grid pattern on the floor of the illusory room. The relationship between the Ames room and the rectangular illusory room is geometrically a 3D-to-3D perspective transformation, where 3D-to-3D perspective transformations are a subset of 3D-to-3D projective transformations, which form a mathematical-group (Myrov et al., 2024). The planarity of the faces and the straightness of the line-segments of these rooms are group invariants of the projective transformation (see Appendix A in Sawada & Farshchi, 2022). The parallelism of the line-segments is not a group invariant of the projective transformation. These line-segments can be regarded as converging towards one another at infinity. Then, their convergence is also a group invariant of the projective transformation. The straightness and convergence are model-based invariants of a 2D perspective transformation from a 3D scene to an image plane. The retinal image of the Ames room is identical to the retinal image of a rectangular illusory room only accidentally. But, there is no accidental local image feature in the identical retinal image.

¹ The “monocular distorted room no. 1” that was physically constructed by Ames did not have the viewing wall and that side of the room was open (see https://www.youtube.com/watch?v=W_5wpPxCcyw&t=1254s). The viewpoint was controlled using a chin-rest.

Some recent articles (e.g. Goldstein, 2007; Rossing & Chiaverina, 2019; Wang et al., 2022; Wickelgren, 2012; Williford, et al., 2022, see also Brecher & Puno, 2010; Gogel & Mershon, 1968; Rogers, 2022; Tyler, 2022) refer to other distorted rooms whose shapes are different from the shapes of the original Ames rooms as “Ames rooms” (Figures 1b-1d). For clarity, these recent “Ames rooms” are referred to as sundry-Ames rooms in this manuscript. The viewing wall of the sundry-Ames room has an identical rectangular shape with the viewing wall of the rectangular illusory room. The viewing holes are at the centers of their viewing walls. The facing wall and one (Figures 1b, 1c) or both (Figure 1d) of the side walls are trapezoids. With these configurations of the sundry-Ames room, its floor and ceiling cannot be planar but are either developable surfaces with folded edges (Figures 1f, 1g) or non-developable surfaces (Figure 1h) so that the retinal image of the sundry-Ames room becomes identical to the retinal image of the rectangular illusory room. Both types of the floor’s non-planarity may be visible if some depth cues are available, such as shading and binocular disparity. The folded edge of the developable surface connects either of the diagonal pairs of corners of the floor and divides the floor into two segments. The non-developable surface cannot be flattened to a plane without partially stretching, shrinking, or breaking. The two sets of parallel line-segments of the rectangular-grid of the illusory room can be projections of two sets of line-segments that form a hyperbolic surface that is the floor of the sundry-Ames room (Figure 1h). Each set of line-segments in the sundry-Ames room are not parallel and not converging to one another, so, their 2D perspective projections become parallel or converging line-segments only accidentally. Both types of non-planar floors of the sundry-Ames room introduce additional accidental features, so, the retinal image of the sundry-Ames room can be identical to the retinal image of the rectangular illusory room but this is more accidental than the retinal image of the original Ames room. These accidental features can make the illusion unstable.

The origin of the sundry-Ames room is not clear but it could be a result of accumulated misunderstandings. Gregory (1966, Stewart, 1974) showed a top-view of his “Ames room” whose viewing wall had a hole at the middle between its left and right edges. This is a common property of the sundry-Ames rooms. This property is also present in an “Ames room” whose retinal image cannot be identical with the retinal image of an illusory rectangular room (JoVE Science Education Database, 2023).

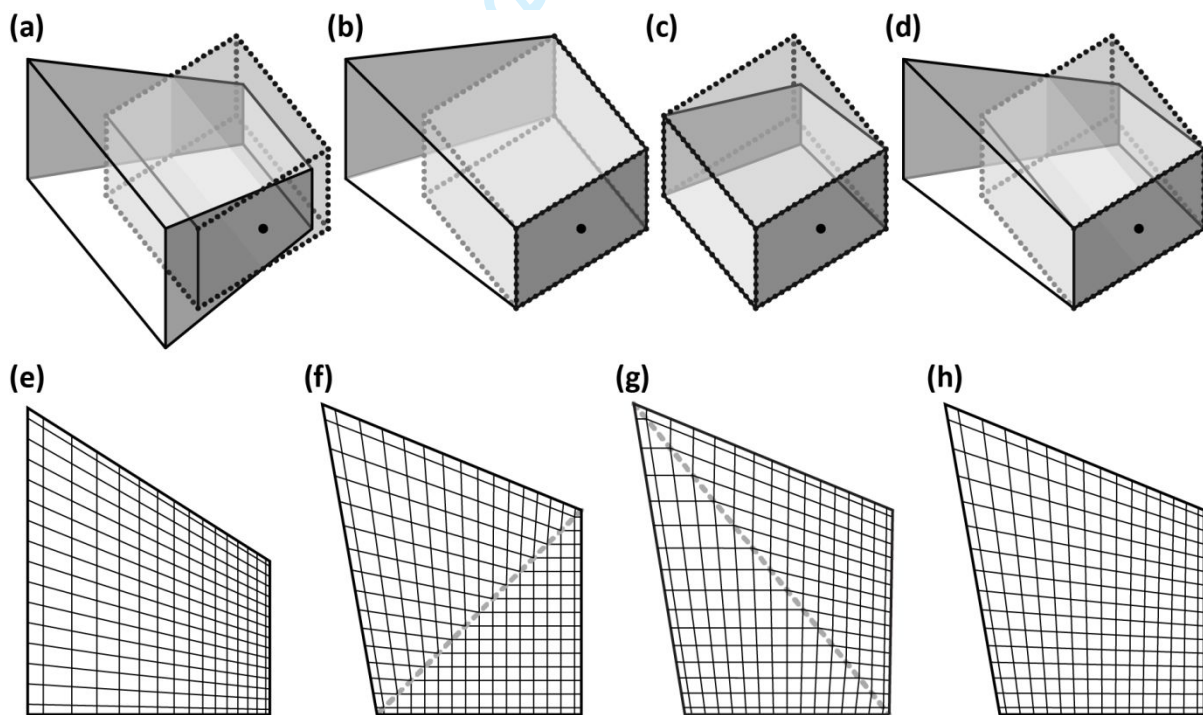


Figure 1. (a) The original Ames room (solid) and its rectangular illusory room (dotted). (b-d) Three types of the sundry-Ames rooms (solid) and their rectangular illusory rooms (dotted). (e) The distorted-grid pattern on the floor of the original Ames room. (f, g) The distorted-grid patterns on the developed surfaces of the floor of the sundry-Ames room (b) when the floor has a folded edge (dashed). (h) A top view of the distorted grid pattern on the floor of the sundry-Ames room (b) when the floor is non-developable and hyperbolic (see Brecher & Puno, 2010; Tyler, 2022).

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