Editorial

The Ames room from another viewpoint

A few years ago Richard Gregory (1987), in one of his editorials for this journal, reminded us of the contributions made by Adelbert Ames Jnr to the study of perception. In doing so he drew attention to the experience many of us have had in looking for the first time through a peephole into the interior of one of the strangely shaped rooms that Ames so cleverly devised. The monocular room is hexahedral in form—the floor, ceiling, and the near and far walls are trapezoidal and the side walls rectangular, the floor and ceiling slope sharply from side to side, the windows in the back wall have tilted tops and are different in height and width, and the floor pattern is irregular with the tiles increasing in size diagonally to the far corner. Viewed with one eye through the peephole the room looks perfectly normal. It is cubic with rectangular walls, horizontal floor and ceiling, rectangular windows of the same size, and a regular chequered floor pattern. It comes as a surprise—a shock even—when we look through one of the side windows with both eyes and see how oddly shaped the room really is.

Ames and his collaborators explained the normal appearance of these monocularly viewed rooms in terms of mediating assumptions formed out of purposeful actions—out of our daily experience in the real world.

"... a whole "family" of distorted rooms of vastly different shapes could be built, yet all of them, if our reasoning is correct, should be seen as "normal" instead of some other way because our past experience has made it a "better bet" to perceive level floors, upright walls, rectangular windows, etc. (Ittelson and Kilpatrick 1952, page 48.)"

As Professor Gregory also reminded us, this experience-based view of perception is rooted in the earlier proposals of Hermann von Helmholtz (1909/1962) and his notion of unconscious inference. Ames himself was very much aware of Helmholtz's views (see Pastore 1971).

I wish here to contact this interpretation with data from an earlier project (Sloan 1984) and from some more recent observations. I then wish to propose an alternative explanation in the context of which the Ames-room effect can properly be regarded as belonging within a broad class of illusions. Other members of the class are trompe l'oeil art and apparent depth from flat stereograms. While this might seem an odd assortment of effects to group together they do have a common basis, as I shall point out. Finally, I intend to describe an entirely new effect inside the Ames room and to introduce a much simpler demonstration of the Ames-room effect involving the inside of a cone.

But first a comment on the construction of these rooms. Ames and his group (Ames 1952; Ittelson and Kilpatrick 1952) described various full-size and half-size rooms for monocular and binocular viewing. All are rather cumbersome, extravagant of space, and not easy to shift from one place to another. These difficulties can be avoided by making much smaller rooms out of cardboard or plywood. We are by no means the first to reduce the dimensions of the rooms but perhaps we are the first to make them quite so tiny. We now have a plethora of rooms ranging from dolls-house

---

The assistance of Fiona Dorward in making most of the observations for this editorial, and that of Vladimir Kohout and Rosemary Williams in preparing the figures is gratefully acknowledged.
size to miniature versions only 10–15 cm along an edge. The illusion of a cubic space in our mini-hexahedral, unpatterned interiors viewed through the peephole is as strong as in the larger wooden constructions. The advantage of the small cardboard ‘rooms’ is that they can be made quickly and cheaply in all sorts of shapes and sizes by students whose curiosity is aroused, and they are also very useful for starting fires.

A few years ago in an honours-year project consisting of five experiments with the half-size Ames room No 1, Margaret Sloan (1984) quantified the illusion of a cubic space. Subjects were required to move a short vertical peg along a horizontal track outside the room to match the apparent egocentric distances to the two far corners of the room as viewed through the peephole. These distances were 191 and 101 cm. In the last two experiments this distance-matching task was used to ascertain the effect of ‘purposeful actions’ on the illusion. The interior of the room was plain grey since an earlier experiment had shown that the illusion was approximately the same with this room as that with windows and red and black floor tiles. In the first of these two experiments, twelve subjects spent five 5 min repeated sessions looking about the room with both eyes and exploring it with a longer wooden pointer. They looked around the room repeatedly and, using the pointer, poked at the walls, corners, floor, and ceiling. In the second experiment, three subjects engaged in the same purposeful actions for five 30 min sessions spread over five days. Before and after these activities these very patient subjects matched the monocularly observed distances to the far corners. A significant change in apparent distance never occurred.

Ames (1952) contended that perceptual change comes about as a result of purposeful actions and consequent new assumptions about the meaning of the proximal stimulus pattern. Well, this certainly did not happen for our subjects after looking at the room in full view with both eyes, and poking about in it with a long stick for a total of 2½ hours. Not a smidgen of change was evident. Maybe after a lifetime of living in normal regular rooms, 2½ hours is not quite enough to effect a change in the direction of the real shape of the room. Maybe one should try living and working for a few years in a full-size Ames room, an appealing experiment for one soon to retire. There could be problems in convincing the Australian Research Council that an addition of a strangely shaped living room to one’s house is a justifiable claim on its funds.

In developing a general explanation of veridical and illusory perception, I have proposed (Day, in press) that states of the individual (eg postures, movements, locomotion) and the natural environment (eg observer–object and interobject distance; object size, shape, and movement; edges; brightness; and colour) generate a multiplicity of features at the sensory receptors. These are commonly referred to as stimulus correlates or, more simply, ‘cues’. In the laboratory these cues can be manipulated in a whole variety of ways to generate illusions of both personal states and environmental states. Four classes of cue manipulation have been identified: reducing their number, resulting in loss of perceptual constancy, as in Holway and Borings’ (1941) celebrated experiment; arranging cues for different states so that they conflict with each other, resulting in perceptual compromises, as I have argued in the case of the Poggendorff and Müller-Lyer illusions; generating the same cues for different environmental states, resulting in perceptual instability, as with the Mach book and Schroeder staircase; and contriving cues for states that are not physically present, resulting in the perception of a state of affairs that is not present in reality. It is my view that this last class of manipulations gives rise to the illusion of cubicity in the Ames room.

What Ames did essentially was to contrive the cues for a cubic space in a hexahedral space. Although the far wall of the room is tilted in respect of a fronto-parallel plane, it is trapezoidal in shape; its far corner is relatively long vertically and its
near corner relatively short. In consequence, the monocular retinal projection of this wall is the same as that of a cubic room. Likewise, the lengths of the side walls, the sizes and shapes of the windows, and the floor pattern are such as to project proximal images identical to those of a cubic room seen through the peephole. In brief, the stimulus correlates of a cubic room have been cleverly contrived in a strangely shaped hexahedral room. The outcome of this ingenious contrivance is that we perceive something that is not present in reality—a 'normal' cubic interior.

This manner of manipulating cues is essentially the same as that used by Pozzo in 1707 to produce the proximal stimulus of a windowed dome in the hemicylindrical ceiling of a church in Rome (Pirenne 1970). Amazingly, when we look up into the hemicylindrical space from a specified position we see a dome with towering windows, columns, and a patch of sky. Like Ames's illusion of a cubic room this effect only occurs when the ceiling is viewed from a designated position. From any other point the dome appears to lean over to one side. The Ames effect is also the same in principle as the contrivance of cues for depth in trompe l'oeil art and for retinal disparity in stereograms. The last is among the best known instances of cue contrivance. By building an appropriate disparity into his depthless stereo pair of pictures, and viewing the latter in his mirror stereoscope, Wheatstone (1838) convincingly demonstrated the role of retinal disparity in the perception of depth. There are other examples of cue contrivance and the perception of states that are not present in reality. The main point to be made is that Adelbert Ames Jnr followed in this long tradition of cue manipulation by building the stimulus correlates of a cubic space into his hexahedral rooms.

Fiona Dorward, who has worked with me over the last few years, and I have exploited this notion of cue contrivance by means of our miniature cardboard rooms. One of these small rooms has a square floor. The back wall leans backwards and one far corner is much higher than the other. The square floor appears strikingly misshapen with one far corner appearing acute. We also placed on the floor of a cubic room a chequered floor pattern like that in an Ames room. The square floor now appeared slightly trapezial with the far wall appearing to be tilted back on one side. So much for the argument involving assumptions about rectangular spaces; our rectangular floors can be made to appear trapezoidal either by altering the far wall or the floor pattern.

There is a much simpler but equally convincing way to contrive the appearance of one interior space within another than that devised by Ames. Roll a quarter circle of thin cardboard with a pattern of radiating black and white bars on its surface into a cone and cut the far end at 45° to the axis. The arrangement is shown in figure 1. Now look through the aperture at the narrow end. The inside of the cone appears perfectly cylindrical and the radiating bars parallel-sided. Of course, the proximal

Figure 1. The interior of the cone appears cylindrical with parallel bars and the elliptical end circular.
stimulus pattern is that of a cylinder since the circumference of the cone and the width of the bars increase as a linear function of their distance from the eye. The principle involved is the same as that involved in contriving a hexahedral room to appear cubic—the sizes of interior features vary as a linear function of their distance from the nodal point, and the elliptical cross-section at the end projects a circle at the plane of the eye.

Incidentally, this case of an illusory interior cannot easily be attributed to past experience with cylindrical interiors unless in the unlikely event one spends a good deal of time living in a tunnel. There’s scope for an experiment there.

I have deliberately saved our most striking demonstration, ‘the impossible table’, until last. We placed a small table on the floor of our half-size Ames room (Ittelson and Kilpatrick 1952). The rectangular table-top measured 34 cm × 17 cm and the legs were all 13.5 cm. When we viewed the interior through the peephole with one eye, the tilted floor as usual appeared horizontal and the interior of the room cubic. However, the table was markedly tilted; one end was much lower than the other. The surprising feature was that, although the table was tilted from end to end on a flat floor, its legs were the same length. Maybe they were very slightly shorter at the lower end but nothing like enough for the tilt of the table top. This is a three-dimensional impossible situation. The whole scene is dominated by the characteristics of the proximal stimulus pattern; the contrived dimensions of the room generate a stimulus at the eye identical to that of a flat-floored cubic room, and the uncontrived stimulus for a tilted table, a tilted table. And that is what we see. The situation is shown in figure 2. The eye sees more or less exactly what the camera records in this photograph.

Figure 2. ‘The impossible table’.
This odd—even eerie—experience would seem to rule out a role for experience-derived assumptions. I cannot recall having experienced too many tilted tables with legs of the same length on perfectly level floors. Certainly, I have never purposively sat at one. The only contribution of the perceptual system beyond processing the stimulus pattern itself seems to be that of an ever so slight compromise between the length of the legs and the tilt of the table top. Question: will a table with one pair of legs shorter than the other pair and the top parallel appear to be so? That is, would we see a level table with legs at different lengths on a level floor? I think we would.

There is another way of making my point. When we contrive the stimulus correlates for one state of affairs, and exclude other cues that might reveal the real state of affairs, perceptual constancy breaks down completely. Instead of perceiving the real situation we perceive one dictated entirely by the proximal stimulus pattern. Thus perceptual constancy is not only eroded by removing cues as Holway and Boring (1941) did, but by contriving new ones as Ames (1952), Pozzo (1707; in Pirenne 1970) and Wheatstone (1838) did.

Thus we can by artistry, artifice and clever laboratory techniques contrive the proximal stimulus patterns for states that are not part of the real world. Artists do it to charm us, entertainers to amuse us, and laboratory scientists to unravel the complexity of cues that normally bring the real world to us via our perceptual systems. Their techniques are the same, their motives different.

R H Day

References
Ames A, 1952 The Ames Demonstrations in Perception (New York: Hafner Publishing Company) pp 1-130
Day R H, “The foundations of veridical and illusory perception” in Issues in Attention and Perception Ed. B Ballesteros (Amsterdam: Elsevier) in press
Gregory R L, 1987 “Analogue transactions with Adelbert Ames” Perception 16 277-282
Helmholtz H von, 1909/1962 Handbook of Physiological Optics Volume 3 (New York: Dover, 1962); English translation by J P C Southall for the Optical Society of America (1924) from the 3rd German edition of Handbuch der Physiologischen Optik (Hamburg: Voss, 1909)
Holway A H, Boring E G, 1941 “Determinants of apparent visual size with distance variant” American Journal of Psychology 54 21-37
Ittelson WH, Kilpatrick F P, 1952 “Equivalent configurations and the monocular and binocular distorted rooms” in Human Behavior from the Transactional Point of View Ed. F Kilpatrick (USA: The Institute for Associated Research) pp 41-55
Pastore N, 1971 Selective History of Theories of Visual Perception 1650–1950 (New York: Oxford University Press)
Pirenne M H, 1970 Optics, Painting and Photography (Cambridge: Cambridge University Press)
Sloan M, 1984 The Ames Distorted Room and the Transactionalist Theory of Perception Psychology Honours Report (Monash, Australia: Monash University)
Wheatstone C, 1838 “On some remarkable and hitherto unresolved phenomena of binocular vision: Part 1” Philosophical Transactions of the Royal Society of London 128 371-394