E. H. Gombrich, The 'What' and the 'How': Perspective Representation and the Phenomenal World R Rudner and I Scheffler (eds), Logic and Art: Essays in Honor of Nelson Goodman, 1972, pp.129-49 [Trapp no.1972G.1]

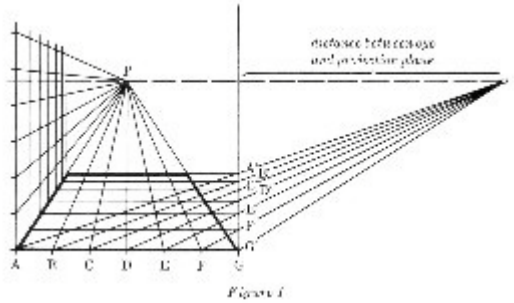
PHILOSOPHY THRIVES ON argument. Thus I hope it will not be taken as a breach of decorum if a contribution to a *Festschrift* attempts to clarify a point of disagreement between the recipient and the author. In *Languages of Art*[1] Nelson Goodman has persuasively argued against J. J. Gibson and me that "the behavior of light sanctions neither our usual nor any other way of rendering space; and perspective provides no absolute or independent standard of fidelity". The first question which this statement invites is "Fidelity to what?" It is to this question that this essay has initially to address itself, before it can attempt to introduce some fresh arguments into the ancient debate about perspective.

Some time ago, while vacationing in the Austrian Alps, my eyes fell on a picture postcard that showed a splendid view of the upper reaches of the Inn valley towards the Swiss frontier. It looked as if it would be worth seeking out the place from which the photograph had been taken. Since I neither doubted its fidelity, nor was unaware of the behavior of light, I took a map and a ruler and attempted to plot the vantage point by the direction of the river and the parts of the vista visible on the picture. We then set out with the card and the map and were rewarded by the beautiful view. Not quite, though: we saw the valley along the same axis, but the card proved that certain distant mountains had also been visible to the camera which showed less on our horizon; the photographer must have stood a little higher, at a spot where it was too late for us still to climb. But this discovery, of course, did not shake our confidence in the method of plotting the spot. On the contrary, it was due to that method. Whatever we may mean by "ways of rendering space" we all rely on photographs or topographical views to tell us *what* objects in space can be seen from a given point. Clearly, we also know that the relationship between maps and such pictures is reversible. Just as a picture can be located on a map, so a map allows us to construct a picture.

Let us imagine a law case that depends on the account of a witness who claims to have seen through the hole in a fence, one night, how the window of a house opposite was lit up and the accused took an object out of a chest of drawers. There would be two methods for the defense to check this claim. One would correspond to my walk: he could take the jury to the spot and demonstrate *ad oculos* that the chest in question could not be seen from that spot by anyone. But such a procedure would not be necessary if the plan and elevation of the house and the fenced garden were exactly known. In such a case it would be easy to work out exactly how much of the room could be seen from the hole in the fence. We need only draw such straight lines from the point from which the witness claims to have watched across the window into the room to specify exactly what objects can have been visible to him and which were occluded. Should he change his story and now claim that he saw the movement through a mirror on the wall of the room, or merely its shadow cast by the lamp on the ceiling, this, too, could be worked out with relative ease. Nor will the situation change dramatically if we allow our hole in the fence to have been large enough for the witness to have watched with two eyes. The disparity of the information that was transmitted by the two retinas is of vanishing relevance at the distance that interests us here. And even if we alter the story and let the witness claim to have walked to a given spot where he had freedom of movement, we can still say exactly what he can or cannot have seen from any given point, even if he used binoculars or turned them round to increase his field of vision. To return to the abstract proposition on which agreement should be easy : given an accurate map of any three-dimensional array and indication about the transparency and refraction indices of all the bodies in this array, any other visual aspect of this array can be mapped indicating which features would be visible and which occluded for an observer at any point of the map. It is a transformation for

which a computer can be programmed, and it is precisely this transformation that traditional one-point perspective performs.

The famous demonstration by Brunelleschi of the newly discovered laws of perspective (Figure 1) can indeed be formulated in this way.[2]



The architect took up his position inside the Florentine Cathedral at a given distance from the open door and showed that he could map out exactly what of the baptistery and the other buildings opposite could be seen from where he stood. If he placed a grid or a net in front of the open door, he could make his prediction increasingly precise and specify exactly what of the view would appear in which of the squares of the net—at least down to the margin of binocular disparity. To eliminate this margin he could always resort to a peephole, and thus he was able to put his theory to the test that a knowledge of euclidean geometry and of the "behavior of light" alone sufficed to construct an image in a peepshow which matched exactly the vista of the buildings opposite the cathedral door that could be obtained from the spot he had selected. If he chose to draw this image on a flat panel opposite the peephole, the laws of geometrical projection would come into play which state that planes parallel to the picture plane—for instance the central facade of the baptistery—would appear in the projection as reduced in size but similar in shape—parallels remaining parallels and identical windows identical windows. The same laws also postulate that it would be different for solid bodies. A sphere, for instance, would only project as a circle when seen head-on along the central axis. As soon as it was shifted to the side of the axis, its projection would deviate from the circular form and approximate an ellipse. Not that this fact invalidated the peepshow experiment. For through the peephole the lateral ellipse on the flat board would be seen foreshortened and therefore "corrected" into a circle.[3]

The oddity of such distortions has been used ever since to question the claim that perspective projection shows us the world as we see it. We do not know if Brunelleschi ever made such a claim. What is relevant is rather that perspective allowed him to map what was seen through that door. If that claim were spurious, we would not now find the piazza swarming with tourists equipped with all kinds of cameras to record and remember the sights they see. For the camera is so constructed that it also maps this information on a flat plate or piece of paper, and that the resulting image obeys as far as possible the laws of projection, minor distortions which are discussed in the literature on optics being "corrected" to make parallels come out parallel.

Is this how we see the world? It is an odd and indeed a misleading question.

Nelson Goodman is certainly right when he protests that the behavior of light does not tell us how we see things. It is doubtful whether, standing in the cathedral, Brunelleschi could take in more than a fraction of the vista at a time; he had to change his focus and since the area of focussed vision is very small, he had to sweep his eye across the opening thus obtaining a succession of different images, rather than one. This is true even though Brunelleschi was careful to select a relatively narrow field of

vision which could be taken in without turning the head.[4] The situation becomes much less tractable when we leave the inside of the cathedral and return to our Alpine scenery. Old-fashioned guidebooks sometimes contain fold-out panoramas from such points of vantage that allow us to identify what we see. The representational accuracy of these diagrams is as easily checked as was our picture postcard. The triangular mountain above that ridge is Mount A., the steep rock on its right belongs to the range of B., and the three houses down in the valley stand on the outskirts of C. which happens to be hidden from us by the slope on which we stand. But here we come at last to a crucial point, for if we claim the same fidelity for the panorama that we have claimed for the picture postcard we are caught in the very contradiction Nelson Goodman had in mind when he denied any objective standards in these matters. For clearly a series of picture postcards do not add up to such a panorama. We can easily check this if we take a series of photographs of the wide vista, turning the camera till we have recorded the whole view. If we then want to join them together, fitting their edges where the vistas overlap, we quickly discover that the result deviates from the fold-out panorama. The panorama was a strip, bounded by parallels, but our composite picture fans inwards, the groundline forming the circumference of a polygon, each individual photograph having to be cut to the shape of a trapezoid, converging towards the horizon. If we wanted to take in the sky, say the cloud formations, the relation would be reversed and the lines would diverge downwards. Not that all this is surprising. The map of a panorama could not be projected onto a flat piece of paper. It could only be accommodated on the inside of a sphere with the horizon as the equator, and other features distributed accordingly. One could imagine such a panorama drawn inside a trans- parent globular shelter on a mountaintop, which would indeed match the outlines of all features of the view as we stand in the center and turn on our heels, at least if we are willing to make the minor adjustments demanded by binocular disparity (negligible for distant views) and by the asymmetries of our body.[5] No doubt, such a panorama too could be drawn from a map by a computer.

Are, then, both methods right? Can it make sense to claim "fidelity" for perspective as a record of what can be seen from a fixed point by a stationary observer, and at the same time to accept the demand that a correct map of what is seen from a given point when we turn our head must ,be curved? It is certainly true to say that to project the world in which we look round onto a flat plane is to distort it. In this situation the map of the horizon labours under the same difficulties as does the map of any part of the globe.[6] In projecting it onto a plane we must compromise the accuracy of geometrical relationships. The larger the area covered, in both cases, the more noticeable will these distortions become. They hardly matter in the map of a town, but they do affect the shape of a continent. *Mutatis mutandis* this also applies to our mapping or photographing vistas. The wider the angle that is taken in, the more the fidelity of the picture will appear to be compromised; the smaller the section, the smaller the distortion.

But the plea that the distortion in a perspective picture is "only a little one" will hardly satisfy its critics. The rival claims of the curvilinearists[7] and the straightliners in perspective which have led to a new Battle of the Books cannot be shrugged off in this way. It is obviously Nelson Goodman's conviction that both can make out an equally good case, which has led him to his relativist conclusion.

And yet, we must pause to ask what it is we are really trying to map when we draw a panorama. We are certainly not confronted with a real spherical object such as the globe, but rather with an apparent one, such as the vault of heaven. It is because we tend to relate the distant view to this imaginary vault that we so strongly feel the need for a spherical map. Unlike the map of the curved surface of the earth, therefore, it will be an attempt to map appearances rather than reality; it will seek to record the "how" rather than the "what" and this, admittedly, is not solely determined by the behavior of light.

I hope that this distinction alone may explain why I remain an unrepentant straightliner, but at the risk of monotony I should like to restate my case in a form that may perhaps further the argument a little. I must, for this purpose, return to the eyewitness story of the room observed through a window. Theorists of perspective have always been fond of rooms with checkerboard floors and walls (Figure 1), and we may imagine the place of the alleged crime even more perfectly patterned with all the walls and the ceiling covered by the grid. I hope it will be agreed that our knowledge of the behavior of light will tell us exactly which squares will be visible and which occluded by the walls of the house, the furniture in the room, or any other feature from where the witness saw it. This mapping, furthermore, would certainly have succeeded if he drew the observed fact onto a flat paper. Indeed this map would have coincided with a tracing of the view he could have made on a vertical transparent plane while keeping his eye still. It is true that he might equally have chosen to make the tracing on a curved plane, say on a bow window, and provided he had kept his eye still, the two tracings would coincide from that point of view. So, by definition, would also the straight lines of the patterned room.

"We know all that", the curvilinearist would reply", but it does not alter the fact that our visual space is curved". It is a reply that has gained some superficial plausibility by Einstein's discoveries, but much as I have had to read, as an art historian, about methods of "rendering space", I have still failed to grasp what this is supposed to mean. If light rays are bent in gravitational fields so that stars appear to be displaced, occlusions will no longer occur along straight lines, and the mapping of the constellations will have to be revised. But nobody has claimed, to my knowledge, that occlusions here on earth are not the consequence of light moving along straight lines, and it is in these I am interested rather than in "space".

I admit that the example of the room is somewhat weighted as an ideal case, particularly if we look at it head on as in the standard diagram. But my argument would not be affected if, instead of one room, we would imagine a whole expanse of a facade with all its windows lit up, for even then one point perspective would tell us how much of each room was visible from the point. What would be disturbing in such a larger map would only be that it becomes increasingly unrealistic. Who would glance at windows sideways or upwards, and how much would he then see anyway? It is for this reason that wide-angle snapshots look so strange; they do not remind us of a possible experience, the inspection of occlusions in one direction.

But what is important is that these same occlusions would also have to be entered on the curved map. If we should really keep the eye on the same spot while moving—by no means an easy feat and one that would involve us in walking in a circle—the windows projected on the inside of the globe would still reveal the same aspects through the windows, though their images would now differ in size and be curved.

The standards of fidelity of the two informational maps would be the same, precisely because neither of them represents "space" but things in space of which no stationary view can give us complete information. What we took for a room in the first example, after all, might have been a stage setting or an "Ames Room" with a sloping or even a curved floor, and what we took for a large chest of drawers, occluding six square foot units, might have been small and oddly shaped. Outside the range of binocular disparity it is only movement that allows us to detect such tricks—the very tricks of perspective. Rotation of the eye on one spot would not suffice here either.

What is characteristic of the experience of space, I believe, is precisely the feeling that we *can* move and test the various aspects of things. We ought not to be surprised that this experience cannot be

recorded on any one informational map; the wonder is rather, as we shall see, that perspective renderings appear less rigid than they are.

Even so, we may grant for argument's sake that rigidity is untrue to our experience of a world in which we can turn and move, and we might do justice to this objection by having the original map drawn, not on a rigid surface, but on some elastic material, a piece of rubber that could be stretched or contracted. Using this expedient, we could then take our map and adjust it to the panoramic circle, curving its straight lines without upsetting its information content.

But would we really have been well advised on our trip in the Austrian Alps to copy our picture postcard onto a sheet of rubber before setting out to identify the view? It showed us *what* could be seen from that spot. No device could fully show us *how* we would see the view.

It is this inability of any representation, of course, that prompts Nelson Goodman to dismiss the claims of perspective. He reminds us of the well-known fact that photographs offer their surprises and disappointments to those who have seen the view : "Pike's Peak dwindles dismally in a snapshot" *(Languages of Art,* p. 15). It is as familiar and as justified a complaint as the corresponding stricture that "the photograph of a man with his feet thrust forward looks distorted" *(ibid.).*

Apparently, then, we would have to manipulate our elastic map considerably to approximate our phenomenal world; we would have to extend the area of the peak and contract the spot with the feet thrust forward. Here, however, one could not but agree with Nelson Goodman that none of these operations would be likely to be very successful; there are indeed no objective standards by which it should be done. For our phenomenal world is not only "elastic", it is in constant movement. There is the change of focus and of accommodation; there is the distortion due to astigmatism and other flaws in our vision; there is, above all, the effect of our own movement which stretches and dissolves the informational map into a fluctuating succession of images. Within this flux of events we selectively single out points of interest, and this attention in its turn acts perhaps as magnifying glass extending the map here and blurring the shrinking areas elsewhere. Whether this phenomenal world of ours can be more easily described, let alone represented, than can the elusive images of a dream, is indeed an open question; and Nelson Goodman is right when he insists that it nowise "looks like" a picture drawn in perspective or in any other way.

I believe it is J. J. Gibson who has most fully explained why we shall never succeed in thus pinning down our visual sensations.[8] Our senses, in his terminology, are "perceptual systems" : they exist to process the stream of information that reaches us from the world; and they are exceedingly well attuned for this task. It is for this reason that he has proposed what I have elsewhere called his "Copernican Revolution",[9] the theory that it is futile to ask how we construct the world out of our sensations, because it is in fact the invariant three-dimensional world that is given to us. What the child and the unsophisticated—and presumably the animal—responds to is the world out there. Concentration on our visual sensations is a product of reflection which was largely due to the development of the pictorial arts. There may be difficulties in the way of this formulation, but I am sure it comes closer to the truth than does the traditional account. But if it does, we shall have to reformulate the problem of perspective representation, without, if possible, dismissing it as irrelevant.

I have attempted precisely this in *Art and Illusion*[10] when I suggested the paradoxical formulation that the world does not look like a picture but a picture can look like the world. The standard of fidelity, to use Nelson Goodman's terminology, is asymmetrical. Philosophically it may look monstrous to say that while a is unequal to *b, b* equals a, but it is this monstrosity I have proposed and should like to

defend and reinforce. The world, we have seen, never looks like a picture mainly because we move through the world and in doing so we are guided by the transformation of aspects that occurs all around us. Moving towards a door, the shape of the door remains invariant but its size changes ; moving past a table, its aspects change in a predictable manner. Predictable to our perceptual system but not to our awareness. Few people could describe, let alone draw these transformations which depend, of course, on the behavior of light. But it is this melody of change, as Gibson has shown, that allows us to perceive the invariants and to inform us of the shape of things in our surroundings in an unambiguous way. From this point of view it makes no sense to ask whether we see straight lines as curved or straight. We perceive them as straight if they are straight; though we all can play interesting games if we try for once to attend to our sensations : Moving in a car along the road we can see the roadside swing round past us in a complex curve, due to the fact that the parallactic shift is much greater in our proximity than it is further along. If we focus on a point on that road somewhere in the middle distance, we shall see the road pivoting around that spot which has become our temporary reference point. These are experiences that always accompany our movement, but few people may be aware of their character. They have no need to know them.

I would suggest that the same is true of the dwindling of "Pike's Peak" and of the so-called distortion of proximal objects, in other words, of all the phenomena that have been subsumed under the term of the "perceptual constancies". As long as psychology talked in terms of visual sensations, these were described as somewhat anomalous adjustments which the mind carries out in viewing the visual field. The mountain 'looks larger' than it should, the feet smaller. But as soon as we adopt Gibson's approach, this formulation will not do. The feet always look the size and shape they are, and even the distant mountain looks large because it is large. And yet it would be clearly wrong to attribute the size from which the constancies deviate simply to the whims of perspective. Though painters may have been among the first to be aware of that effect, we can all experience it without resort to drawing or to a psychological laboratory. For the so-called constancies may be described as the degree of unexpectedness of what will occlude what in our field of vision.

Take two oranges of unequal size, or two unequal coins, and try to hold one so as to precisely occlude the other. It will not be very easy to fix this place without trial and error, for we are normally not much concerned with these relationships in our line of sight. If we then move the occluding shape sideways so that both objects can be seen side-by-side, we tend to experience a shock of surprise, for the smaller one will persist to 'look' small, though we have just found that their images must be equal. There are many variants of this experiment, from drawing the view on a windowpane to measuring the size of one's mirror image on the mirror's surface. Each of these experiences, familiar to every painter still trained in the skill of perspective, will tend to confirm the feeling of unreality with which we look on relations of occlusion.

Why are we so rarely aware of them? Is it not because normally they are of little practical relevance? In reaching out for the orange on the table I adjust my hand to its real size which I shall soon be able to test. The fact that in the eourse of this movement my thumb may for a moment occlude its total width is of no significance and is 'gated out'. J. J. Gibson may well be right in his surmise that nobody could be interested in the relative sizes. of images in the plane before painters investigated them. Even the painter, however, tries for obvious reasons to avoid those extremes that Nelson Goodman has referred to —the oversize hand or foot. Why are they avoided? Once more the explanation suggests itself that in real-life situations we rarely have occasion to attend to such occlusions. If a small object cuts out a large part of our field of vision, we simply shift our head and are rid of the obstruction. It is only where our movement is impeded, as when we sit in a theater and are bothered by the size of the hat of the lady in front that we notice the laws of perspective that make it obscure

half the stage. Even so it is not quite true that such occlusions will always look unrealistic. In the motion picture the rapid enlargement of an object can make us duck.[11] We are attuned to the behavior of light, even though we do not know it.

Indeed it seems to me that some of the constancy phenomena described in psychological literature can best be interpreted in the light of the role that expectations of movement and therefore of transformations play in our processing of visual information. Take the well-known experiment by Robert H. Thouless which aims at measuring what he calls "Phenomenal Regression to the Real Object" .[12] The subject was asked to look from a given point at a circular coin lying on the surface of a table and to select from a series of graded ovals the one he thought would match the foreshortened coin. It was found that the shape selected always deviated in the direction of roundness from the shape calculated on the basis of projective geometry. It looked as if the coin were tilted towards the observer.

In Thouless terminology the appearance was a compromise between the real object (which is circular) and the real projection (which is a steep oval). I have argued elsewhere that the term 'real' here is perhaps a little misleading. What the experiment shows is that we tend to anticipate the effect of an inspection movement. If we wanted to find out the shape of an object, we would either turn it in our hand or move in relation to it, till we got it into full view. Somehow this expectation colors our awareness of what we see to such an extent that even the demand to find out which cardboard shape would match or occlude the object in question fails to elicit the correct response. After all it is a complicated demand : we must predict when and how an unfamiliar piece of cardboard held vertically would coincide in its outline with a familiar coin on the table over there. Real life never poses this question, while real life often makes us carry out inspection movements. Thus we generally underrate the degree of tilt because it will soon right itself.

The Thouless experiment reminds us to what an extent our perspective representation on the flat rubber sheet would have to be pulled about to adjust to these various influences on apparent size and apparent shape. The distant coin not only looks larger but also rounder than it "should", just as Pike's Peak not only looks taller but also steeper than it turns out to be when you measure its slope against an occluding pencil. The case against the phenomenal world looking like its projected picture on a plane is indeed even more formidable than Nelson Goodman has made it.

But these arguments overlook a fact which we neglect at our peril: the picture, too, is part of the phenomenal world, and if the phenomenal world bends, turns and twists, so surprisingly does the perspective representation. It is possible to show that we do in fact tend to pull it about, and that the degree to which we do it is generally ignored or at least underrated.

I feel that Nelson Goodman's diagram on page 18 of *Language of Art* is a case in point. He looks for fidelity in the demand that the picture and the view of a high tower should match, and finds that this could only happen in eccentric and unrealistic situations. The illusionistic painters of Baroque ceilings might not have found them quite as absurd as he implies, but that is beside the point. What matters is that pictures are not visually as inert as he seems to postulate. For as I have also tried to argue elsewhere, the so-called distortions due to the constancies and other effects also apply to pictures painted in perspective.

Take the Thouless experiment. I would predict that a painted coin or plate represented as lying on a table would also obey the law of "phenomenal regression to the real object", which I would interpret as an anticipated inspection movement.[13] Indeed it might be possible in this way to devise a measurement for the degree of illusion experienced in front of a painted still life and to examine the

influence that fidelity to the "behavior of light" may have on this automatic reaction. One thing has been shown, perspective representations do lead to that surprise at occlusion which I have described as an aspect of the constancies.[14] A pair of dividers shifted from the foreground of any picture postcard to the features near the horizon will convince the reader that even in pictures we rarely estimate the true extent of diminution with distance.

But naturally the constancies not only operate in the picture, they also operate on the picture. If it is true that coins anticipate our inspection movements, this must also be true of paintings. It has often been said and repeated that a picture 4n perspective will look right only when seen exactly from the center. It is curious how this myth could survive into an age in which persons sit in the cinema, in front of the television set or the projection screen when their friends show snapshots of their holidays without much caring to avoid a slight angle. They know that the picture will look normal, thanks to the constancies.[15]

I believe this phenomenal correction to be both more interesting and more complex than writers on this subject have generally allowed, for if we think the matter through we come to rather startling results.

The first of these results follows from the postulate that pictures seen obliquely will tend to "right themselves" in anticipation of our inspection movement. If this could be verified, it would follow that if we stand in front of a large mural, looking sideways and looking up and down to take it all in, its surface would. begin phenomenally to buckle and curve according to the direction of our gaze. That sharp contrast between the flat perspective projection and the spherical panorama would lose much of its phenomenal reality. A wide panorama of the ocean, for instance, with its horizon painted quite properly as a straight line, might appear phenomenally and almost unnoticeably to curve around us as we turn our head.

But this consequence of the fact that pictures also belong to the phenomenal world must be seen as superimposed on another effect which would at first appear to pull in the opposite direction. I refer to the notorious phenomenal shift in the orientation of objects represented in perspective pictures. I have discussed this intriguing phenomenon twice, once in *Art and Illusion* and again in a later essay on *"Perception and Visual Deadlock",* but I have never been satisfied that my explanation was exhaustive.[16]

It was based, above all, on what I called the "negative test" of consistency. In a painting, an object with a pronounced aspect such as a foreshortened gunbarrel, a pointing finger, or a human eye will continue to show the same aspect from whatever side we look at the picture. If these objects were not painted, but real, any move on our part would of course show them from a different side and reveal a different aspect; since we fail to produce this change, we instinctively assume that the object is still pointing at us and must therefore have moved. The effect is stronger where the object concerned is seen thrusting outward from the picture, because such an object would change its aspect more rapidly than would another, further in the distance. Thus the knife handle in our diagram (Figure 2) will appear to move more than the face of the clock in the background.

I know now that this explanation is incomplete, but it points at least to one important element in the theory of representation which is rarely discussed explicitly—I mean the difference between objects of pronounced orientation (such as a gun or a clock), objects of indistinguishable orientation (such as a sphere), and objects of unknown orientation (such as a tree whose branches may grow in any direction). Once we realize that a perspective projection might correspond to an infinite number of

different arrays in space, it also becomes clear that the configuration on the plane will unambiguously correspond to an object of known shape and orientation only when it belongs to the first of these categories. We can tell where the painter stood in relation to a building or even a pointing gun barrel on the assumption that the building is bounded by a rectangle and the gun barrel was straight. We cannot know the same of a tree or a rock unless we are familiar with its shape or—and this is a complication I prefer to omit—if the additional cue of light and shade brings in another element of orientation.

Now this ignorance of ours as to the real array the painter had before him makes us also more tolerant towards a change of configuration on the picture plane. If it does not correspond to one thing, it may plausibly suggest another.

It is armed with this knowledge that we must try to tackle the problem of the intriguing change in perspective pictures as we walk past them. When in *Art and Illusion* I attributed this "internal movement" in the picture to the way in which "we contribute some of the imagined movement from the store of our own explanation", I was certainly wrong. The movement is real enough. It is of course the result of the foreshortening of the picture as we look at it from the side.

How this foreshortening operates on the plane is a simple matter of projective geometry. If we keep our eyes at the height of the picture's horizon while we move sideways, the line of the horizon itself will shrink but not change in orientation, but lines parallel to the horizon will increasingly converge from up and down towards our vanishing point. The frame will be the most oblique but all oblique lines inside the picture will both get shorter and steeper as the area of the picture contracts. (Figure 2)

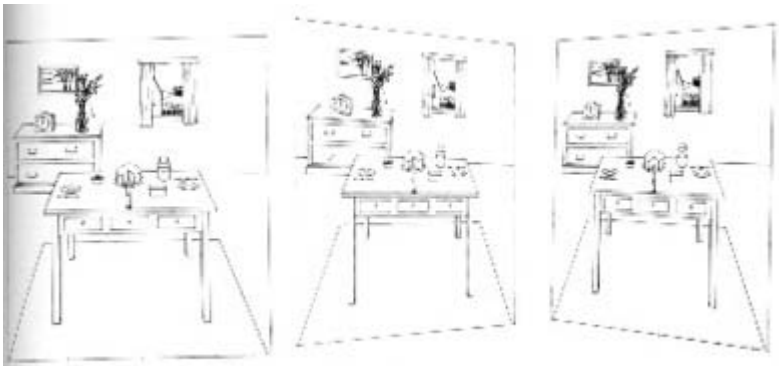


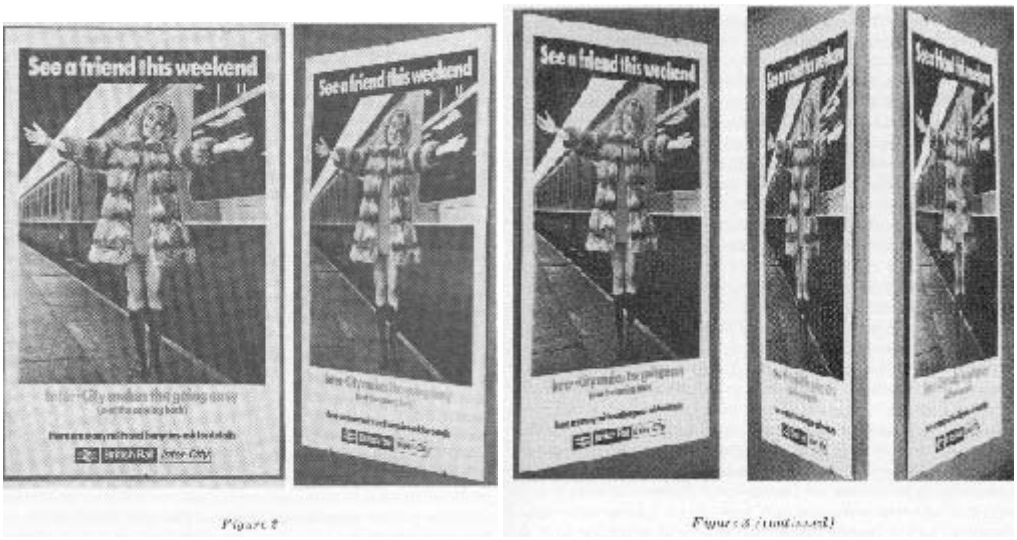
Figure 2

Thus the proportion of every configuration will change and become narrower, the horizontals being more affected than the verticals.

Now perspective is a system of representation in which the orientation and relation of lines is given a particular significance. Lines converging towards the vanishing point of the picture are understood to be at a right angle to the picture plane, and the orientation of other foreshortened objects of known shape is seen in relation to this system.

When it is said that a perspective picture only "works" when the beholder's eye is fixed precisely at the point from which the array was drawn, it is tacitly assumed that only then will the beholder see precisely what the painter saw, and how he saw it. The first is correct, the second doubtful in any but extreme cases of contrived trompe l'oeil. But the way in which pictures adjust to other viewpoints suggests that there is no need for the painter's vanishing point and the beholder's to coincide for a plausible or possible view of a three-dimensional arrangement of things to emerge. If trees appear

taller and narrower, and even persons somewhat slimmer, well there are such trees and such persons. If the young lady on the poster (Figure 3)



who extends her arms to embrace us seems, when seen from her right, to have become asymmetrical, her right arm being longer than her left one (which is further away from us), we need not even suspect her of being misshapen; we need only assume that the arm further away is not shorter but more foreshortened, and the convincing character of the picture is restored. Does not "more fore shortened" also mean that the arm is turned a little more towards us? Of course it does mean precisely this, and so, as we walk along the poster, the lady will go on smiling at us and her arms will turn towards us, not because we 'project' or imagine this movement, but because the unnoticed transformations on the picture plane carry this significance.

The complexity of this transformation is naturally somewhat confusing, but one theoretical point must be made. If a picture is so constructed as to have its vanishing point in the center, as indicated in our diagram (Figure 1), its oblique position will resemble the side-wall of our diagram; this means that the vanishing point will now appear to be along the line D', that is, it will have moved from the center towards the opposite frame. Note that this movement is only relative to the picture. For while we shift our position, the area of the picture will inevitably seem to contract, and this contracting movement will shorten the apparent length of the horizon on which the vanishing point has now become a little eccentric. What accounts for the strong impression of movement, however, is not this slight dislocation of the vanishing point on the picture plane, but its imaginary position on the far-distant horizon. It is towards this ideal point that the orthogonals of the perspective construction are converging, and it is the apparent shift of their orientation that makes for that veering movement which naturally appears to affect the foreground most of all.

At the same time, the narrowing of the whole picture leads to the predicted increase in steepness, and to a relative lifting of the horizon, as if the ground were sloping upwards. The road leading from the horizon outwards towards the center of the picture which abutted onto the frame at a right angle will now form an obtuse angle on the side on which we stand and will thus appear to be leading towards us, QED.

One thing, perhaps, should be added. The actual transformations and shifts affecting every configuration on the plane clearly are of a complexity that not only defies description but also perception at one go. Hence our tendency to select some point of reference in relation to which we

see the 'movement' of the other features, much as we saw the lateral road swinging round a focussed point during real movement. Here is one of the subjective elements that accounts for the feeling that the movement is carried by particular features of interest, the road leading towards us, the gun or the eyes of the portrayed. It is these we take as points of reference, and here what I have called the negative test may well apply. But it is all the more important to stress that the movement as such, the change in the angle relative to the frame, and therefore the change in the degree of foreshortening is real and not imaginary.

The objectivity of these transformations which I have never seen fully described[17] is easily demonstrated by the simple expedient of photographing pictures or diagrams from various angles.

It is interesting and amusing from this point of view to scrutinize art books which show interiors with pictures on foreshortened walls, or similar murals in churches. They will confirm the varying tolerance of different objects to this kind of transformation. Roads leading into the distance fare best, of course, because the shift of the vanishing point simply shifts their apparent direction. Round buildings are also relatively unaffected, because their elongation is not felt to be disturbing. It is different with symmetrical facades parallel to the picture plane, for being closer to the horizon than the lower frame, their bounding lines will be less converging, and so they will appear to have shifted towards the beholder while their central feature has become eccentric.

The few effects here described certainly do not exhaust the way we tend to process and change the phenomenal aspect of a painting seen in perspective. Other tendencies may exert their pull: for instance, the relative importance of objects, or the familiarity of aspects or shapes, such as letters which we always scrutinize for their invariant rather than their changeable features. All these elements get into the mill which churns and transforms the information from the visible world, and they do so because of what Thouless has called the effort after meaning, the desire to make sense of what we see.

But does not this effort presuppose an expectation? Does the way we look at perspective pictures not depend on a certain amount of conditioning? It probably does. It is unlikely that an observer who had never seen such pictures would "see" all the transformations I have attempted to describe. But would that prove that Nelson Goodman or even G.ten Doesschate are right in calling one-point perspective only one of many possible ways of mapping the world? I doubt it, for if I am right, perspective is not only uniquely successful in mapping *what* we see from a given point; the rich and elusive *how we* see perspective renderings may also be unique.

Could other systems of representation elicit the same complex and manifold type of reaction? Questions such as these are more easily asked than answered without experiment. But one experiment has been performed. I refer to the course of historical development that has led to the evolution of perspective representation. It seems to have impressed those who saw it as "better" than other methods, and whether we regret this or not, even the Japanese adopted it when they learned of its existence. How can we explain this undeniable success of perspective if it were only another mapping method that must be learned to be decoded? Is it not more plausible to think that there is indeed something compelling in the trick even though it achieves genuine illusion only in such special cases as in peepshows, on the perspective stage, or on illusionist ceilings seen from the right place?

I have suggested elsewhere that what perspective renderings do more easily is to unsettle our perceptions.[18] However difficult it may be in any individual instance to say "how" we see a

perspective representation, such a representation may still be an exception to J. J. Gibson's postulate that we see the objects of our surroundings precisely as they are.

Pictures constructed on the tightly knit system of perspective (which is imitated by the camera) tend to resist this process. It takes a special effort and much unlearning of reactions to see them merely as things. The very way they dissolve and transform themselves approximates them to that elusive experience we describe as the phenomenal world.

If proof were needed of this elusiveness, it would lie in the types of transformation I have here tried to classify and analyze, for though they may all occur simultaneously, they are logically in contradiction with each other—much as is the panoramic and the static view, or the experience of Pike's Peak as it is and as it appears to be.

To sum up, I have attempted to separate three ways in which the perspective picture is stretched or transformed : The first corresponds to the Thouless effect of the constancies and demands that objects in paintings that are drawn as tilted will appear slightly more turned to the beholder than they are really represented. The second, which should be based on the same tendency, would demand that the picture itself, frame and all, would appear less foreshortened than it is; and yet the third, which is the most important and the most interesting, is precisely based on the objective and unnoticed transformations in the plane which are due to this foreshortened view. Introspection suggests that the three actually co-exist peacefully. As our attention shifts in its search for meaning, all the pulls and counterpulls that shape our phenomenal world come into play in the processing of pictures. Maybe it is precisely this paradoxical type of transformation that points to the connection between fidelity and the behavior of light, and therefore to the limits of relativism in representation.

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[1] Indianapolis: Bobbs-Merrill, 1968, p. 19. [129]

[2] I have discussed this famous episode from a slightly different angle in "From the Revival of Learning to the Reform of the Arts: Niccolò Niccoli and Filippo Brunelleschi", *Essays in the History of Art presented to Rudolf Wittkower,* ed. Douglas Fraser, et al. (London: Phaidon Press, *1967), 81-82.* It has been discussed from other points of view by Rudolf Krautheimer, *Lorenzo Ghiberti* (Princeton University Press, *1956),* and John White, *The Birth and Rebirth of Pictorial Space* (New York: Thomas Yoseloff, 1958).

[3] Cf. Gezienus ten Doesschate, *Perspective, Fundamentals, Controversials, History* (Nieuwkoop: B. de Graaf, 1964), which seems to me the most balanced and authoritative treatment of this subject

[4] Like other authors, Nelson Goodman appears to think that the eye must be strictly stationary. This is not correct, as Doesschate has shown *(op. cit.* chapter XII) and as the reader can verify if he places himself inside a room and attends to the view appearing through a window. A change in the direction of his gaze may blur this view but will not change it. As soon as he turns his head, of course, other things will come into the view in the window, for the head is pivoted on the neck, and any turning means a lateral displacement.

[5] See note 4 above.

[6] See Ralph M. Evans, *Eye, Film and Camera in Color Photography* (New York: John Wiley and Sons, 1959).

[7] For the problem of curvilinear perspective see also Kenneth Adams, "Realism in Painting", *Discovery* (July 1962), and my comment in the subsequent number of that Journal.

[8] James J. Gibson, *The Senses Considered as Perceptual Systems* (Boston: Houghton Mifflin, 1966).

[9] "The Evidence of Images", in C. S. Singleton, ed. *Interpretation, Theory and Practice (Baltimore: Johns Hopkins Press, 1969).*

[10] New York: Pantheon Books, 1960), 329.

[11] See my paper "Visual Discovery through Art", *Arts Magazine* (November 1965), now reprinted in James Hogg, ed. *Psychology and the Visual Arts* (Baltimore: Penguin Books, 1969).

[12] Robert H. Thouless, "Phenomenal Regression to the Real Object", *British Journal of Psychology,* 1931, vol. 21, reprinted extract in M. D. Vernon, ed. *Eperiments in Visual Perception* (Baltimore: Penguin Books, 1966). I have discussed this experiment in *Art and Illusion.*

[13] For a demonstration see R. L. Gregory, *Eye and Brain* (London: Weidenfeld and Nicolson, 1966) , 172.

[14] See *Art and Illusion,* p. 304, and my papers quoted in notes 9 and 11.

[15] No less a mind than Einstein addressed himself to this problem in a letter to M. H. Pirenne quoted by Doesschate, *op. cit,* p. 158. He speaks of the beholder "easily compensating for the distortion on condition that the visual angle . .. is small". This "compensation" is precisely the constancy phenomenon. I hope to show further below that other factors also play their part.

[16] In *Meditations on a Hobby Horse* (London: Phaidon Press, 1963).

[17] The only systematic discussion I know is in the brief chapter X of Doesschate, *op. cit.,* who treats it from the point of view of distortion. [146]

[18] See note 9.