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# ON MY CONCEPT OF PERCEPTUAL PERSPECTIVE THAT ACCOUNTS FOR PARALLEL AND INVERTED PERSPECTIVE IN PICTORIAL ART

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**Abstract**—*The author discusses his concept of perceptual perspective based on normal visual perception of nearby objects, which accounts for parallel and inverted perspective used in pictorial art in different parts of the world. His general conclusion is that these two kinds of perspective convey the geometry of visual perception of nearby objects more accurately than does geometrical or linear (scientific) perspective developed during the Renaissance period. He points out that inverted perspective exaggerations that can be found occasionally in pictorial art do not refute his general conclusion about the validity of inverted perspective for the depiction of nearby objects.*

## I. PERCEPTUAL PERSPECTIVE OF NEARBY OBJECTS

Inverted perspective, employed in the depiction of objects on a flat surface so that their dimensions are shown to increase rather than decrease with distance from their viewers, is found in pictorial art of pre-Renaissance art in Europe and Asia, for example in Italy, Russia (icons), Persia (miniatures) and China. (The styles of pictorial artworks are discussed in Refs. 1, 2.) Perspective in pictorial art has long attracted the attention of researchers [3]. The analyses with which I am acquainted are directed to the question of why some artists deviated in their depictions from what they actually saw. My thesis is that these artists did not really deviate; they used inverted and parallel perspective in an effort to depict in an undistorted way what they saw.

Recently, I described in *Leonardo* [4] the use of my concept of *perceptual perspective* for examining the perspective employed by Cézanne in his pictures of landscapes. This concept takes into account both the function of the eyes and of the brain in visual perception. The brain's function is particularly evident when one looks at nearby objects and when such objects are depicted in pictures. Attention to the brain's function has been drawn by V. Ronchi [5].

It has been pointed out that the types of perspective employed in Hellenic, European medieval and Asiatic pictorial art differ from that of geometrical or linear or scientific perspective developed later during the Renaissance. (In this article I refer to the latter as *Renaissance perspective.*) It is important to note that the former artists who made pictures depicted nearby objects (as in Russian icons), for they were not interested in those seen at long range or in their disposition in space. (Matters related to this have been discussed, for instance, by E. Panofsky [6].) It is, therefore, necessary to consider the principles governing the visual perception of nearby objects, which involves basic information on the psychology of visual perception and mathematical means for treating visual data. My experiments and detailed calculations pertaining to this matter are presented in the appendices in my book [7], so I shall limit myself here to a non-mathematical discussion of the results obtained.

Basic to the concept of perceptual perspective is the phenomenon of *size constancy* [4]. In the perception of nearby objects, size constancy is almost full, which means that parallel straight lines are perceived as parallel and that *parallel perspective* for depicting nearby objects is correct, as I have confirmed for the concept of perceptual perspective. Renaissance perspective with lines projected to a vanishing point on the horizon is satisfactory only for depicting objects at a large distance from the viewer. The concept of perceptual perspective embraces parallel perspective not only for the depiction of small and nearby objects but also the perspective for those seen from afar. The concept clarifies why parallel perspective has been used not only for depicting nearby objects, such as parts of interiors, furniture, etc., but also distant buildings, as in Russian icons, Chinese medieval pictures, etc.

In order to increase the scope of a figurative picture, some artists have successively changed the direction of their gaze and their viewing points. As a result, in a picture, each object is depicted in a parallel perspective as seen from a different viewing point or different gaze direction, that is, the picture contains an ensemble of local parallel perspectives. My analysis of pictures utilizing parallel perspective by artists ranging from western Europe to Japan confirms the above statement. Although this subject is interesting, in my following discussion I shall limit myself to pictures in which objects are depicted in inverted perspective.

## II. INVERTED PERSPECTIVE, A LIMITED KIND OF PERCEPTUAL PERSPECTIVE

Imagine a person standing in a room on a floor with a well-defined pattern of parallel lines, for example gaps between boards of wood. When the person looks along these gaps, then at a short distance away (about two to four metres) and in the retinal field of clear vision (foveal vision) they will appear to be parallel, that is, in a parallel perspective. This is readily observed and is confirmed by equations of perceptual perspective.

Now, if these gaps are seen sideways, the equations indicate that in the field of clear vision the gaps will be perceived as diverging, that is, in a slightly inverted perspective. Figure 1 is presented in explanation. Figure 1a is a plane view in which point $S$ represents the viewing point of the person relative to the picture plane $PP$. A board with parallel sides $AB$ and $DC$ is shown on the floor at an angle $\alpha$ with $PP$. Figure 1b shows the convergent and foreshortened image of the board projected on the retina of the person's eyes (this corresponds to Renaissance perspective). Imagine that the distance from the person to the board is short, such that the board lies entirely within the region of full size constancy. Then the sides of the board's image $A_1B_1$ and $D_1C_1$ will be displaced left and right as shown by the arrows, with the longer arrows representing a larger displacement. The result is shown in Fig. 1c where the sides $A_2B_2$ and $D_2C_2$ are parallel (size constancy). But size constancy functions in the direction perpendicular to $PP$ as well as parallel to $PP$, where the

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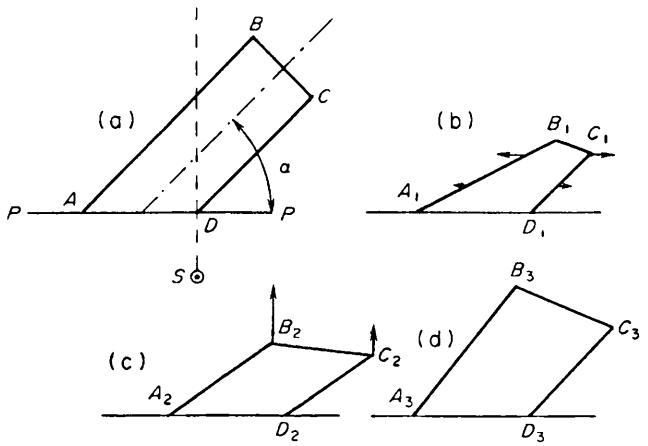


*Fig. 1. Diagram of the process of visual perception resulting in inverted perspective.*

changes are again indicated by arrows of different lengths. The perceived image exhibiting inverted perspective is represented by the final shape shown in Fig. 1d. The amount of inverted perspective perceived will vary with angle $\alpha$ and with other factors, such as the width and length of the boards. According to my calculations, the maximum effect of inverted perspective (the maximum angle between $A_3B_3$ and $D_3C_3$) is about 10°. Thus human vision in inverted perspective is quite possible. I propose that artists who used inverted perspective in an archaic style of picture conveyed what they actually perceived.

One might question this proposal, but one must bear in mind two circumstances: (1) The above-described perception concerns only a rather small region of clear vision. A much larger surrounding region of peripheral vision lacks this perception. The clearly visible inverted perspective is surrounded by a large region that is not seen as clearly but is seen in a perspective that is close to the Renaissance geometric one. (2) Persons in industrial societies from early childhood are subjected to intensive conditioning for Renaissance perspective by pictures they see at home and in school and, especially, by images provided by photography, cinema and television. This conditioning leads them to believe that parallel straight lines invariably are seen as converging to a vanishing point on the horizon.

Having found theoretically the possibility of perceiving objects in a slightly inverted perspective, I also verified its actual occurrence. Many persons to whom I demonstrated this possibility now can recognize seeing nearby objects in inverted perspective. It is interesting to note that they do not find such a perspective to be unnatural; they are simply surprised they have not noticed it before. This may explain why children frequently draw objects in such a perspective.

So it follows from the above that persons are capable of interpreting their view of nearby objects in slightly inverted perspective, providing that the objects are fully incorporated in the retinal field of clear vision. Medieval artists who depicted household articles made the depictions from memory on the basis of daily experience. For example, when moving about a room, they saw objects from different viewpoints with different foreshortenings (different angles $\alpha$ in Fig. 1), and, consequently, they could see one object now in a parallel perspective and then in a slightly inverted perspective. This explains the seeming 'eclecticism' of pre-Renaissance European and Oriental artists. Different objects may be depicted in one picture either in parallel or in inverted perspective. This is not a reflection of artistic inconsistency but an accurate registration of the fact that nearby objects are seen in both kinds of perspective.

By turning to certain artworks, such as European icons, manuscript miniatures, frescoes, mosaics and related works in other cultures, one easily finds examples of these two kinds of perspective.

My mathematical analysis and demonstrations of perceptual perspective provide a simple explanation for inverted perspective. Still, this concept contradicts the commonly held one that only Renaissance vanishing point perspective is correct for the depiction of objects. I, therefore, deem it useful to describe another way of showing that the inverted perspective is verified.

In 1947 R. K. Luneburg [8] put forward the idea that in the region of binocular vision (which differs substantially from monocular vision only for nearby objects) objects are perceived in terms of Riemannian space of negative curvature (Lobachevskian space). Luneburg's idea has been developed subsequently both theoretically and experimentally by mathematicians and psychologists of visual perception mainly in the U.S.A. (see, for example, the article by A. A. Blank [9]). If one accepts conclusions arising from Luneburg's idea, the following problem may be posed and resolved:

Imagine a person looking at a floor on which a square is depicted. The plane of the floor will become the person's visual perception in a plane of non-Euclidean space. It can be shown that in this perception the image of the square will assume the shape of the so-called *Lambert's quadrangle.* One property of such a quadrangle is that its far side is larger than its near one. And this corresponds to inverted perspective! I have cited this in my book [7] as a solution of the problem of whether a person sees nearby objects in inverted perspective. But the depiction of nearby objects does not involve only how horizontal planes are seen but also how (3)-dimensional objects are seen. This complication I shall discuss below.

## III. EFFECTS OF SHAPE CONSTANCY

The mathematical equations describing perceptual perspective were obtained by taking into account a fundamental attribute of visual perception—size constancy. Shape constancy is beginning to play an important role at small distances between viewer and object (along with size constancy). It can be explained simply as follows: In visual perception the perceived form of an object is closer to its actual form than the 2-dimensional image of it in a photograph. For example, a viewer of a television screen, when looking at it sideways, interprets the shape of the screen as a rectangular shape seen at right angles to it, not elongated in the way a photograph of the screen would appear taken from the same position.

The shape constancy effect can be demonstrated by considering how one may draw a stool, for example. The demonstration will also give support to the idea that it is not possible to draw on a flat surface precisely what is perceived [4].

Figure 2A presents, in parallel perspective, a stool close to its viewer; only size constancy has been taken into account. For an object at close range, however, shape constancy should also be taken into account. When this is done, the seat of the stool, assumed to be square, is perceived not as shown in Fig. 2A, but as in Fig. 2B. Although the seat in 2B is also not a square, it approaches one, that is, the angles of its corners are closer to a right angle. Having depicted the seat of the stool as perceived, artists will face the difficult task of depicting the stool's legs. In variant Fig. 2B the rear legs are elongated, and in variant Fig. 2C they are detatched from the floor. Clearly, each of the three drawings does not depict precisely what is perceived. My belief that it is not possible to draw on a flat surface precisely what one perceives is supported by the fact that one cannot depict the stool's seat as shown in Fig. 2B while simultaneously depicting the stool's legs as of the same height and as resting on the floor.

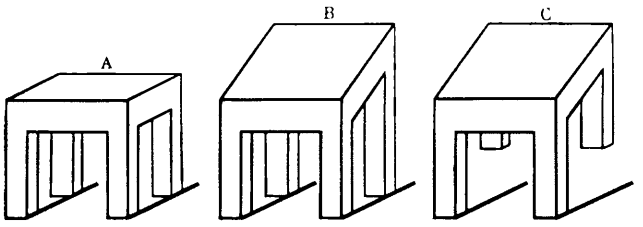


*Fig. 2. Three variants of depicting a stool.*

Wishing to depict a stool, artists must accept one or the other type of distortion. Some artists have definitely preferred to utilize the Fig. 2B variant of depiction. Apparently the reason is that the functionally most important part of an object, for example the seat of a stool, is conveyed more in accordance with normal visual perception. On a seat depicted in that way a person can be shown seated more naturally, and, when a tabletop is depicted in the same way, it is easier to depict the objects situated upon it. It is significant to note that the use of the variant of depiction in Fig. 2B leads to the introduction of inverted perspective—indeed, the rear legs of a stool or of a table do appear to be taller than the front ones.

Although inverted perspective as actually experienced and as employed by artists in pictures are two different matters, I maintain that these artists tried to depict accurately how nearby objects are seen in terms of rules that account for the main geometrical aspects of such objects. One can find examples of the three variants shown in Fig. 2 in their pictures. The variant of Fig. 2C was often used for depicting objects with short legs or none, for instance of sofas in miniatures by artists in Persia and India, of pedestals supporting the feet of saints in European medieval pictures and of similar objects in Russian icons.

## IV. EFFECTS OF INVERTED PERSPECTIVE

There is a mathematical theorem stating that it is not possible to transfer the perceived shapes of a 3-dimensional object into a 2-dimensional surface, such as the plane of a picture, without distorting some of them. This, no doubt, was understood long ago by those who make pictures. In different cultures different rules were adopted for the depiction of objects by deciding which distortions should be either avoided or minimized. This may account partially for the fact that many artists have a feeling of freedom, since they exercise the 'right to distort' selectively in their pictures what they actually see. The arbitrary geometrical rules, adopted for depicting objects, could be expected to lead to liberation from providing illusionistic copies of objects and to a value being placed on artistic expression. A part of this kind of expression led to the introduction of *perspective effects.*

Consider a building whose plan is rectangular and whose facade is parallel to the picture plane. If it is desired to depict the right and left sides of the building as well as the facade, this may be done by choosing three different viewing points. This will lead to the plan's being trapezoidal instead of rectangular with front narrower than the rear, as in inverted perspective.

In the above example the desire to provide more information about an object led to the appearance of inverted perspective. A desire to enhance the expressiveness of a picture may also result in its appearance (for a discussion of this topic see Ref. 3).

In some Byzantine and Russian icons one finds both nearby objects and buildings in the background depicted in very accentuated inverted perspective. This practice and other ways of providing visual effects are important in these icons, for they have significance in terms of the Orthodox Catholic religion [7, p. 211] [10].

## V. DISCUSSION

Since my concept of perceptual perspective accounts for the correctness of slightly inverted perspective for the depiction of nearby objects, I find it fallacious to assess pictures that make use of inverted perspective for nearby objects in terms of the perspective developed during the Renaissance [4]. I find surprising the way Renaissance perspective has achieved dominance in figurative pictorial art, especially in European cultures and cultures stemming from them.

When analysing pictures in which those who made them utilized either parallel or inverted perspective, it must be borne in mind that they were concerned with depicting nearby objects. Evidently, these kinds of perspective are not correct for the depiction of, for example, landscapes as humans perceive them (in this connection, see Ref. 11).

Those who analyse figurative pictorial art in which inverted perspective has been used, I suggest, must take into account these possible factors involving an artist's intention: (1) to depict accurately what was perceived; (2) to introduce distortions to provide more information on the appearance of objects depicted and (3) to produce expressive effects that have significance in terms of aspects of a society's culture.

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