

Art in the Realist Ontology of J.J. Gibson

Synthese 54 (1983) 71-83. 0039-7857/83/0541-0071 \$01.30

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DAVID R. TOPPER

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The concept of the Real, some would suggest, exists in a state of unstable equilibrium. If nudged, ever so slightly, it will slip into the world of illusion and hallucination; and as fantasy replaces fact so truth, beauty, and knowledge dissolve in the muddle of relativism. But if, in fact, the situation is that desperate, what role may visual art play in such a world? Little, it seems. Indeed, from this point of view, art might be viewed as a threat, potentially encroaching upon the territory of the Real.

The late psychologist James J. Gibson almost viewed art that way. Although primarily a psychologist of visual perception in general, picture perception was a specific topic that ran throughout his life work.¹ And, as his ideas about perception changed over the years, so did his explanation for picture perception. Over an approximately thirty year period Gibson moved more and more toward a Realist ontology; namely, that our visual perception of the world is direct, without mediation of any sort. Although his final formulation was cloaked in contemporary jargon about information, ecology, invariance, and the like, Gibson's point was simply that there is a real world and we really see it.

He therefore potentially was confronted with Plato's plight: once the Real is demarcated, anything else (such as art) becomes unreal. This is ironic, of course, because Plato's "Real" (a world of nonexperiential ideas) was the antipode of Gibson's. Yet what they had in common was a sense of an immediate grasp of a "Real" without any mediating factors. For Gibson the gap between sensation and perception was to be closed. Indeed the evolution of Gibson's ideas could be described simply as the closing of that gap.

I've been told that Gibson was fond of art, that many pictures hung in his home and office. He also was acquainted with the art historian E. H. Gombrich, who holds an adjunct professorship at Cornell University where Gibson taught. Gibson once told me that he enjoyed the visits of Gombrich, particularly the friendly debates. Yet as his concepts of perception evolved, the role of art in that visual world fluctuated: once holding a central place, later seemingly dismissed as [71] hollow, and finally re-entering at the heart of Gibson's theory of perception. Part 2 of this paper is the story of those fluctuations for art. Part 3 is an assessment of the final formulation of Gibson's theory.

2.

In 1971 Gibson outlined the progress of his ideas of picture perception [13]. He saw three stages in that development (which began about 1950), each stage spanning approximately a decade. Hence the 1970s comprised the third (and, as it was, the last) decade. But with the benefit of today's

hindsight I should like to challenge his scenario, and argue instead that underlying the semblance of discontinuities there was actually a gradual and continuous evolution toward a Realist ontology.

The seeds of this Realism were sowed in Gibson's first book, *The Perception of the Visual World* (1950) [5]. The most important notion there was the distinction between the "Visual World" and the "Visual Field," a distinction that (despite changes in terminology) was sustained in his writings over the next (almost) thirty years. Basically the terms differentiate between two ways of looking at (or attitudes toward) the visual environment. The "Visual World" is "the familiar, ordinary scene of daily life, in which solid objects look solid, square objects look square, horizontal surfaces look horizontal, and the book across the room looks as big as the book lying in front of you" [5, p. 26]. On the other hand, one may "look at the room not as a room but, ... as if it consisted of areas or patches of colored surface, divided up by contours.... The attitude you should take is that of the perspective draftsman. It may help if you close one eye. If you persist, the scene comes to approximate the appearance of a picture" [5, pp. 2-27]. This other attitude toward the environment he called the "Visual Field."

It is clear that the Visual Field is germane to art, or (more specifically) to picture perception. Indeed, he wrote of the Field as having "a pictorial quality," and that "the field of view can be seen as a picture" [5, p. 33]. But he emphasized that "pictorial seeing.. . differs astonishingly from ordinary objective seeing" [5, p. 42]. By "ordinary seeing" Gibson meant, of course, the perception of the Visual World. But why the adjective "objective"? The reason is that he believed knowledge of the Visual World was primary, and [72] the Field secondary; i.e., the latter is derived from the former. Thus he asserted that "the objectivity of our experience is not a paradox of philosophy but a fact of stimulation. We do not have to learn that things are external, solid, stable, rigid, and spaced about the environment." In other words, there are no mediating factors, for "the objective world does not require for its explanation a process of construction, translation, or even organization" [5, pp. 186-87]. This "objective world" was the Visual World, not the Visual Field.

The consequences for art were portentous. The concept of the Field - with its pictorial quality - was a "substitute" for the traditional idea of sensations. But by making the World objective, Gibson was taking a major step toward closing that gap between sensation and perception. Once closed, sensations disappear, being relegated to the realm of myths. And pictures (a sub-set of the Field) must apparently be banished too. But such radical confrontations would come later. For now, much effort was required for coming to grips with that "objective" world.

Gibson accounted for our knowledge of this "objective" world by borrowing the concept of an invariant from mathematics. In topology "a series of transformations can be endlessly and gradually applied to a pattern without affecting its invariant properties. The retinal image of a moving observer would be an example of this principle" [5, pp. 153-54]. Since the retinal image is the projection of solid objects onto a curved surface, then underlying the many transformations of this image there are invariant properties analogous to those in the geometry of transformations. "Only these properties would be capable of providing the stimulus basis for a stable and unchanging visual world" [5, p. 154]. As the book's title indicated, it was this "objective" Visual World that was the focus of attention. He charged that students of perception have spent too much effort (theoretically and in the laboratory) pursuing the "Field."

A year later, in 'What is a Form?', he made the same point. "It will be argued here that drawings are particularly inappropriate objects with which to begin a study of the perception of form" [6, p. 404]. As before Gibson switched the traditional assumption about vision: our knowledge of the Visual World is primary and not derived from the Visual Field (which, according to him, is, in fact, secondary). Hence

"the primary problem for psychologists is to isolate the invariant properties" of the world [6, p. 411]. What role, if any, [73] remained for pictures in the laboratory? They were useful, Gibson said, only for understanding the "special theory of picture perception" [6, p.411]. Having thus isolated the subject, and deemed it so remote from reality, it seemed that picture perception would be ever eschewed from Gibson's work.

The next year, however, he published the following remark, which was subsequently expanded into a bold hypothesis about picture perception. "The Visual Field, I think, is simply the pictorial mode of visual perception, and it depends in the last analysis ... on conditions of attitude. The Visual Field is a product of the chronic habit of civilized men of seeing the world as a picture" [7, p. 149]. As far as I am aware, Gibson did not develop this thesis until his next book in 1966.

In the meantime he published two papers on picture perception. 'A Theory of Pictorial Perception' appeared in 1954, the theme being that "a picture conveys information" [8, p. 4]. He even went so far as to propose a definition of a realistic picture. "A faithful picture is a delimited physical surface processed in such a way that it reflects (or transmits) a sheaf of light-rays to a given point which is the same as would be the sheaf of rays from the original to that point" [8, p. 14]. At the core of this definition are the principles of projective geometry in the Visual Field. In other words, however faithful a picture may be to the original scene, it remains as "experience at second hand" [8, p. 4].

Six years later, in 'Pictures, Perspective, and Perception,' he returned to these issues. Taking into account that a caricature may appear as a "faithful" picture too, Gibson modified his definition, by fixing upon the notion of information. Now a picture "delivers a sheaf of light rays... that contain information about... a world which is not literally present..." [9, p. 221]. In 1971, Gibson commented upon this paper, asserting that he had "amended ... considerably" the 1954 definition, and hence launched the second phase of the development of his ideas [13, p. 28]. But however much that first definition was modified, more important was the continuity of concepts from the previous decade. Indeed, a few sentences following the second definition was the statement that picture perception is "a perception at second hand - a vicarious acquaintance with an absent scene". As was put forward ten years before, the distinction between the World and Field was the keystone, with pictures being a subset of the Field. [74] Gibson put it this way: when viewing the World we "isolate the invariant properties of things - the permanent residue of the changing perspectives," whereas the artist "catches and records for the rest of us the most revealing perspectives on things" [9, p. 220]. Potentially such a view might be significant, even if it were only "perception at second hand."

That significance emerged in Gibson's second book, *The Senses Considered as Perceptual Systems* (1966). Here, as before, he stressed the distinction between invariant properties of things and their changing perspective viewpoints, a distinction he reiterated in a series of papers in Leonardo in the early 1970s [13, 15, 16]. Not surprisingly, he posited that when seeing an object in the environment one normally sees the total object, not only the front surface. In other words, the object is seen as if one were walking around it, even if the viewer does not, in fact, move. By perceiving an object in this manner, one is "visualizing without a point-of-view" [16, p. 41], and, therefore, seeing the invariant features of the object. He referred to this way of seeing as the "naive attitude," or as "seeing the non-change underlying the change" [13, p. 32]. Most acts of perception in the everyday environment are made in this "naive" manner. If, on the other hand, one perceives an object by (say) closing one eye and seeing only the front surface, the viewer perceives a single perspective of the object. By looking at an object in this manner - what Gibson called the "perspective attitude" - one sees the object as a "frozen patchwork of flat colors confined by the boundaries of the temporal field of view" [13, p. 32]. He also called this "perceiving with a point-of-view" [16, p.41]. Normally, however, one does not

perceive objects in this way; generally the invariant features are seen, and it is only in extraordinary cases (as when looking at things with one eye closed, as some artists often do) that the viewer perceives the perspective features (or "aspects") of objects.

But, more importantly, Gibson put forward a bold hypothesis about the birth of art, a speculation that led to a debate with E. H. Gombrich. According to Gibson, the pre-historic cave painters (the first known artists in western culture), in attempting to draw animals on the walls of their caves, were the first to notice the perspective features of objects in the environment. In 1966 he wrote:

To see an animal in perspective requires doing so from the front, side, back, or above. (The cave artists chose the profile exclusively.) I am suggesting that men had not paid [75] attention to the perspectives of things until they learned to draw and to perceive by means of drawings. Before that time they needed only to detect the specifying invariants of things that differentiated them - their distinctive features, not their momentary aspects or frozen projections. Young children are also, I think, not aware of aspects or forms as such until they begin to notice pictures as surfaces [11, p. 236].

Gibson repeated this hypothesis five years later by asserting that our primitive ancestors, before the discovery of pictorial representation by the cave painters, had never noticed the perspective features, or aspects of objects and the perspectives of the environment. They could only take the naive attitude toward the world. Why should the Ice Age hunters have noticed that a mammoth had a different appearance from the front, the side, the rear and above? Why should they have observed that a thing appears to get smaller as it gets farther away? What use would there be to have paid any attention to linear perspective, and vanishing points and the optical horizon? But as our ancestors began increasingly to make pictures they began to notice these appearances. They began to see aspects, perspectives, in short forms. The man who painted the mammoth on the cave wall had to notice and remember one aspect (usually the side view) since the necessity of making tracings on a flat surface required it. And so it was, I think, that some men began sometimes to take the perspective attitude in viewing the environment. They began to be able to see the world as a picture. But they had to learn to do so [13, p. 32]

This radical hypothesis - that before the creation of art there was no perception of the perspective features of objects - Gombrich challenged, noting that he was "sorry to deprive painting of the central role in man's awareness of himself which Professor Gibson has assigned to it" [20, p 49]. Gombrich's argument was summarized by the following example:

Nobody who has ever walked in the mountains can uncritically accept Professor Gibson's theory that we perceive the three-dimensional features of our environment and only learn about aspects from paintings.... Those who are familiar with the famous silhouette that Mont Cervin presents from Zermatt may sometimes be incredulous when the same mountain is pointed out to them from a different vantage point [21, p. 196].

The perception of mountains, therefore, is an example of perceiving with the perspective point-of-view, not the naive attitude; accordingly, "our primitive ancestors" most probably viewed mountains in the same way, even before the advent of painting.

Another variation of Gombrich's argument was presented in the following question directed to Gibson:

I still wonder, for instance, what Professor Gibson would say to a painter who wanted to paint the Mont Cervin out of his hotel room in Zermatt. Would he ask him to tour all [76] the surrounding valleys in order to embody in his picture the invariant features rather than a particular aspect? And what would the finished result look like? [21, p. 308]

Later Gombrich extended his argument to include one's perception of the night sky [22].

A few years later I was reminded of this debate when I came across a story retold by the late Jacob Bronowski [3]. The story involved the account of some European mountain climbers when climbing in the Himalayas, and their encounter with the native climbers in the area. As Bronowski wrote:

Those who have gone out to climb in the Himalayas have brought back, besides the dubious tracks of Abominable Snowmen, a more revealing model of truth. It is contained in the story which they tell of their first sight of some inaccessible and rarely seen mountain. The western climbers, at home with compass and map projection, can match this view of the mountain with another view that they have seen years ago. But to the native climbers with them, each face is a separate picture and puzzle. The natives may know another face of the mountain, and this face too, better than the strangers; and yet they have no way of fitting the two faces together [3, pp. 29-30].

Bronowski went on to quote from the account of one of the European climbers:

On the morning of the 27th we turned into the Lobujya Khola, the valley which contains the Khombu Glacier (which flows from the south and south-west side of Everest). As we climbed into the valley we saw at its head the line of the main watershed I recognized immediately the peaks and saddles so familiar to us from the Rongbuk (the north) side: Pumori, Longtren, the LhoLa, the North Peak and the west shoulder of Everest. It is curious that Angtarkey, who knew these features as well as I did from the other side and had spent many years of his boyhood grazing yaks in the valley, had never recognized them as the same; nor did he do so now until I pointed them out to him [3, p.30].

This story, therefore, gave credence to Gombrich's argument against Gibson's hypothesis, for the story revealed that the native climbers did perceive the perspective features of objects - in this case, mountains, interestingly enough, Gombrich's example - independently of (and before) attempting to draw them. Clearly, the native climbers in this story did not see the invariant features of the mountain, but only single perspectives. The European climbers then taught the native climbers to see the various views as composing one and the same object; that is, to see the invariant features. "Other expeditions in other places," Bronowski remarked, "have told of the [77] delight of the native climbers at such a recognition" [3, pp. 30-31]. Hence, this example did not appear to be an isolated one.

It may, of course, be argued that the perception of a mountain is an exceptional case. But it was precisely this exception to Gibson's hypothesis that cast doubt upon its general application. Specifically, Bronowski's story raised a question about Gibson's reconstruction of prehistoric times: if the natives of the Himalayas were aware of single perspectives of mountains, then surely some (if not most) of the prehistoric cave dwellers (before the advent of painting) also saw mountains (if not most distant objects, as well) from this point-of-view.

Due to such criticism, Gibson was forced to withdraw his hypothesis. Thus in a letter to me he wrote that Gombrich's "criticism therefore (as I have now decided) is just.... The 'chronological priority of the perception of invariant features before perspective features,' as you correctly put it, applies only to objects one can walk around, not to mountains you can't walk around (or celestial objects of any sort)" [17].

What role then remained for art, now that the pre-historic discovery of forms was eliminated? Could Gibson salvage anything from his original hypothesis? The answer was found in his last book [19], where the gap between sensation and perception is closed. Sensation is a myth, and only perception remains - it being the detection of invariants in the environment. But what of the distinction between the invariant and perspective viewpoints, i.e., the original World and Field, respectively? The answer: the perspective viewpoint (or Field) was now conceived of as a special case of the invariant attitude (or World). "A point of observation at rest is only the limiting case of a point of observation in motion, the null case" [19, p.72]. Thus, "the moving point of observation is understood as the general case," and "the stationary point of observation... no longer is conceived as a single geometrical point in space but as a pause in locomotion, as a temporarily fixed position relative to the environment" [19, p. 75]. This leads to the following deduction:

It is important to realize that the flowing perspective structure and the underlying invariant structure are concurrent. They exist at the same time. Although they specify different things, . . . they are like the two sides of a coin, for each implies the other. This hypothesis... sounds strange, as if one cause were having two effects.... But there is nothing illogical about the idea of concurrent specification of two reciprocal things. Such an idea is much needed in psychology [19, p. 76]. [78]

This concept of concurrence is crucial since it modified the previous relationship between the World and the Field. Here is how Gibson once explained it:

I don't believe there is any real issue underlying the distinction between the naive attitude and the perspective attitude in visual perception. We all seem to agree that the distinction between them is valid. The only question is whether or not they are mutually exclusive. If I implied that the two different attitudes cannot be taken at the same time, and that the two kinds of perception are never mixed, I was quite wrong. A sort of in-between perceiving does occur. I don't know why. Perhaps for various reasons [18].

In all of this, Gibson is inferring that the Field is subsumed under the World. The Field, as such, independent of the World, no longer exists. Although this formulation may be a bit awkward and abstract, I believe it can be expressed in concrete terms. Gibson, indeed, does so thusly: "No one ever saw the world as a flat patchwork of colors.... The notion... comes from the art of painting, not from any unbiased description of visual experience" [19, p. 286]. The gap is closed: only invariants are perceived. Artists may think they paint forms and photographers think they capture them, but they do not; they cannot because sensations are a myth.

Like Plato, Gibson seemed to have reached that stage where artists must be banished from the Kingdom - expelled for pursuing a myth. But, in fact, Gibson never took that step; pictures re-entered his system through the concept of concurrence, and moreover as something more than mere second hand experience. Abstractly put, the argument is this:

If it is true that the perception of a detached object is not compounded from a series of discrete forms of that object but depends instead on the invariant features of that family of forms over time, it follows that an arrested member of that unique family will have at least some of those invariants. If object perception depends on invariant detection instead of form perception, then form perception itself must entail some invariant detection [19, p. 271].

Concretely put, Gibson meant that we perceive invariants (not forms) within pictures. And (allowing for

modifications mentioned below, in part 3) the experimental evidence over the past few decades indicates that he was correct [24]. Space is perceived in pictures. For instance:

just as the rim of a plate in the environment is perceived as a circle, so a similar elliptical rim of a painted plate is perceived as a circle in [79] the picture.

We do look into pictures, and in doing so detect the invariants in them, as we do in the environment [29].

Gibson therefore was not compelled to take the plunge with Plato. Although Gibson demarcated the Real, art still found a niche within the boundary.

3.

The keystone of Gibson's last formulation was certainly the concept of an invariant, not only regarding environmental perception but also (as just seen) for the picture perception. Nevertheless problems linger. Granted that space (and therefore an invariant, such as circularity) is perceived in pictures (as in the environment), yet it remains true that in pictures we may become aware of the Field, or the form of things. The two-dimensionality of the Field is often strikingly revealed in a picture. As someone once said: there is nothing like a picture to make a molehill out of a mountain.² Thus, although pictures may not have been the source of our species' discovery of forms in those pre-historic paintings, pictures do make us cognizant of the Visual Field of things - the occluding of objects, the convergence of parallel lines, the distortions of circularity, and so forth. Pictures therefore do deliver more than mere secondhand experience of the World.

Pictures, thus, may be the source of our awareness of features in the environment that would otherwise be missed or ignored. But if this be so, is not Gibson's concept of an invariant accordingly placed in jeopardy? Because what, in fact, is invariant perception? With regards to space perception, solidity may be an invariant, but all perception is not space perception. To borrow an example from Rudolf Arnheim: "If someone looks at the autumn colors of trees, are the colors the essence of the trees or are they accidental and therefore not subject to perception" [1, p.122]. The implications are clear: there is no a priori distinction between essence (invariant) and accident (variant) [25, 26].

Without slipping into relativism, I believe we may speak of the multipartite nature of visual perception: humans may attend to a wide-range of possible features of our environment. And here art plays a vital role; in particular the history of European art displays this opulence of visual experience. Thus the Florentine artists of the [80] fifteenth-century explored the geometrical forms of things; whereas, in the same century, the Flemish artists were obsessed with the texture of cloth, hair, wood, jewels, and the like. From the glitter of glass and metal there developed, by the seventeenth-century (particularly in Holland), a fascination with the manner in which light is reflected from objects. This concern with light culminated two centuries later in the Impressionist movement, its quest being a portrayal of the world as a 2-dimensional array of light and color at a particular moment. An apt termination of this movement was pointillism: a view of things almost like a Cartesian plane, with a different color at each (X, Y) point [28].

All of these styles were squarely within the Realist tradition of European art, yet each called attention to different features of the visual environment. But, in turn, artistic attitudes may dovetail into World perceptions. To give one example: consider the seventeenth-century Baroque architecture of

Francesco Borromini. The assessment among eighteenth-century Neo-Classical historians was that his flamboyant structures were too excessive, that he "created inventions in bizarre taste." By the nineteenth-century Borromini was still accused of "annihilating" all sense of "order and proportions." Yet, surprisingly, upon completion of his most complex building (San Carlo in Rome) a contemporary had written: "Everything is arranged in such a manner that one part supplements the other ..."3 To be sure, viewers in all three centuries saw a building when looking at Borromini's structures. They were neither dreaming nor hallucinating. Nor may we speak of any one as being more "naive" (or "essential") than the others. Each perception of Borromini's buildings was, like my present stare at my desk, an attitudinal mode of vision of the environment. Yet the implication is not that physical objects in that environment subsist on the same ontological plane as dreams and fantasies, or hallucinations and delusions. The multipartite quality of visual perception rests upon a concept of the Real that exists in a state of stable equilibrium.

"Go out to walk with a painter," wrote Ralph Waldo Emerson, "and you shall see for the first time groups, colors, clouds, and keepings."4 However much Gibson wished to close the gap between sensation and perception, I suspect he would have enjoyed that walk.

University of Winnipeg [81]

NOTES

1 The evolution of Gibson's thought from the point of view of picture perception is found in [5-19]. Since this article was written, Ben-Zeev's detailed study of Gibson [2] has appeared; his discussion of the general theory of perception corroborates mine, but the paper only contains one paragraph on picture perception [2, p. 135].

2 The saying is found in Goodman [23, p. 15]. A discussion of Goodman's argument is in [30].

3 These quotations may be found in [217].

4 Emerson is quoted in [4]. The term "keeping" is seldom used today. It means the proper maintenance of relations between nearer and more distant objects in a picture, and in the last century was generally used for the concept of compositional harmony.

REFERENCES

[1] Arnheim, R.: 1979, 'Some Comments on J. J. Gibson's Approach to Picture Perception', *Leonardo* 12, 121-22.

[2] Ben-Zeev, A.: 1981, 'J. J. Gibson and the Ecological Approach to Perception', *Studies in History and Philosophy of Science* 12, 107-39.

[3] Bronowski, J.: 1965, *Science and Human Values*, Harper and Row, New York.

[4] Davis, D.: 1980, 'Small Worlds', *Newsweek* (January 7), p. 61.

[5] Gibson, J. J.: 1950, *The Perception of the Visual World*, Greenwood Press, Westport, Connecticut (1974 reprint).

[6] Gibson, J. J.: 1951, 'What is a Form?' *Psychological Review* 58, 403-12.

[7] Gibson, J. J.: 1952, 'The Visual Field and the Visual World: A Reply to Professor Boring,' *Psychological Review* 59, 149-51.

[8] Gibson, J. J.: 1954, 'A Theory of Pictorial Perception,' *Audio-Visual Communication Review* 1, 3-23.

[9] Gibson, J. J.: 1960, 'Pictures, Perspective, and Perception,' *Daedalus* 89, 216-27.

[10] Gibson, J. J.: 1961, 'Ecological Optics,' *Vision Research* 1, 253-62.

- [11] Gibson, J. J.: 1966, *The Senses Considered as Perceptual Systems*, Houghton Mifflin, Boston.
- [12] Gibson, J. J.: 1967, 'New Reasons for Realism,' *Synthese* 17, 162-72.
- [13] Gibson, J. J.: 1971, 'The Information Available in Pictures,' *Leonardo* 4, 27-35.
- [14] Gibson, J. J.: 1972, 'A Theory of Direct Visual Perception,' in *Psychology of Knowing*, ed. 3. R. Royce & W. Rozeboom, Gordon & Breach, New York, pp. 215-36.
- [15] Gibson, J. J.: 1973, 'On the Concept of "Formless Invariants" in Visual Perception,' *Leonardo* 6, 43-45
- [16] Gibson, J. J.: 1974, 'Visualizing Conceived as Visual Apprehending without any particular Point of View,' *Leonardo* 7, 41-42.
- [17] Gibson, J. J.: January 3, 1978, letter to the author.
- [18] Gibson, J. J.: March 6, 1978, letter to the author.
- [19] Gibson, J. J.: 1979, *The Ecological Approach to Visual Perception*, Houghton Mifflin, Boston.
- [22] Gombrich, E. H.: 1969, 'The Evidence of Images,' in *Interpretation, Theory, and Practice*, ed. C. S. Singleton, Johns Hopkins Press, Baltimore, pp. 35-104. [82]
- [21] Gombrich, E. H.: 1971, 'Letters,' *Leonardo* 4, 195-97 & 308.
- [22] Gombrich, E. H.: 1974, 'The Sky is the Limit: The Vault of Heaven and Pictorial Vision,' in *Perception: Essays in Honor of James J Gibson*, ed. R. B. MacLeod & H. L. Pick jr., Cornell University Press, Ithaca, New York, pp. 84-94.
- [23] Goodman, N.: 1968, *Languages of Art*, Bobbs-Merrill, Indianapolis.
- [24] Kennedy, 3. M.: 1974, *A Psychology of Picture Perception*, Jossey-Bass, San Francisco.
- [25] Topper, D. R.: 1977, 'On Interpreting Pictorial Art: Reflections on J. J. Gibson's Invariants Hypothesis,' *Leonardo* 10, 295-300.
- [26] Topper, D. R.: 1979: 'Further Reflections on 3. J. Gibson's Hypothesis of Picture Perception,' *Leonardo* 12, 135-36.
- [27] Topper, D. R.: 1980a, 'Review of A. Blunt's Borromini,' in *Technology and Culture* 21, 95-7.
- [28] Topper, D. R.: 1980b, 'On Abstraction as Concept and Process in Art and Science,' in *Perception, Cognition, and Representation II: Presentations on Art Education Research*, No.4, ed. E. J. Sacca & J.J. Victoria, Concordia University, Montreal, pp. 7-40.
- [29] Topper, D. R., Simpson, W. A.: 1981, 'Depth Perception in Linear and Inverse Perspective Pictures', *Perception* 10, 305-12.
- [30] Topper, D.R.: 1984, 'On the Fidelity of Pictures: A Critique of Goodman's Disjunction of Perspective and Realism,' *Philosophia* 14, 187-197.