Color: A Comparative Study in Jain Perspective

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Abstract

Matter, the important constituent of cosmos, is characterized by sense properties color, smell, taste and touch in Jain metaphysics as well as in modern science. There are five primary colors in Jainism. A substance, gross or subtle, is an aggregate of infinite number of *paramanus*, the smallest indivisible particle, and necessarily possesses all the five colors but only one or a few of them manifest at a time, the others remain un-manifest. Color is an objective property of matter in Jain metaphysics but the perceived color also depends on the state of the sense organ, the eye, and the source of light and so it may vary. In modern science color is perception of frequency (or wavelength) of light and is a combination of three things the light source, the object and the observer; the color is not objective. Scientific phenomena such as Raman' study of color, Doppler Effect, effect of Gauge and perception of color through Cuties are reviewed and it is shown that they support the Jain proposition that color is objective property of matter.

Matter

In Western Philosophy matter is conceived as one of the ultimate principles or substances; the physical world consisting of material substances with qualities and relations. It possesses color, taste, etc., and the capacity of motion and the nature of dissociation and combination. According to Jain metaphysics, the most visible form of *Ajivadravya* (Non-living substance) is *pudgala* (matter) which exists in the Universe in various forms. The characteristic attribute of *pudgala* is that it possesses the properties, which can be perceived by sense organs viz. color, smell, taste and touch [1]. Concomitance of all the four is emphasized by the Jains. In other words, if a thing is perceived by the sense of touch, it must also necessarily possess smell, taste and color. All mutation of matter must possess all the four qualities as follows.

- Five types of primary color : Black, blue, red, yellow, white
- Five types of taste: Sweet, bitter, pungent, sour & astringent
- Two types of odor: Good smell and bad smell.
- Eight types of touch: Cold, hot, smooth (positive charge), rough (negative charge), light, heavy, soft and hard.

All colors, tastes and smells can vary in degree and a large range of colors, tastes and smells are possible.

Based on above qualities the material substances in nature are of three types.

(i) Substance having one color, one smell, one taste and two touches.
(ii) Substance having five colors, two smells, five tastes and four touches.
(iii) Substance having five colors, two smells, five tastes and eight touches.

Pudgala *paramanu* is the two-touch substance; it has only one color, one smell and one taste. The four-touch substances comprise the subtle (*suksama*) class of matter, which exist in energy form. The eight-touch substances constitute the gross class of aggregates comprising energy and matter. Thus according to Jaina all aggregates, containing a large number of *paramanus*, necessarily possess all colors, smells and tastes. Generally only one or a few of the colors, smells and tastes manifest at a time, the others remain in un-manifest state. The manifestation of colors etc. is dependent on the mode of the substance. Some attributes manifest in the natural mode while some other attributes manifest in the alienated modes. The manifestations are both intrinsic and extrinsic. For example, some colors, smells and tastes manifest in a fruit in the green state and other colors, smells and tastes manifest in the ripen state.

Color

In any sensory perception, there is an interaction between the sensory apparatus and the sensory quality existing in the object. The sensory quality, which is comprehended by us in our perception, is actually created as a result of interaction between the sensory quality existing objectively in the object (the external world) and the sensory apparatus (of the body). Thus, the taste of an apple as perceived by us is created by the interaction between the objective taste existing in the apple and our tasting apparatus i.e. tongues.

The sensory quality of 'color' is slightly different from other qualities, here the sensory apparatus (eye) does not come in direct contact with the object but perceives it through the medium of light. Thus, the color, which is comprehended in our perception, is created as a result of the interaction between the objective color existing in the object, light and the optical apparatus.

Theories of Color [2]

The following theories of color have been proposed.

1 Objectivism

Objectivism is the most prominent view of color. According to this view color is an objective, i.e. mind-independent, intrinsic property, one possessed by many material objects (of different kinds) and light sources. This view, however, takes different forms.

(a) Primitivism. This is the view that colors are simple qualities, which show their nature on their face: they are *sui generis*, simple, qualitative, intrinsic, non-relational, irreducible properties. They are not micro-structural properties or reflectances, or anything of that sort. There is no radical illusion, error or mistake in color perception (except common place illusions), we perceive objects to have the colors that they really have.

(b) Physicalist Color Realism. This is the view that colors are objective (mind-independent), properties of material bodies and light sources, whose natures are "hidden" from us, and require empirical investigation to discover. Here the colors are light related properties e.g. capacities to emit, reflect, absorb, transmit or scatter light to varying degrees.

2 **Color Elimination/Irrealism/Fictionalism (or Error Theory)**

These all share the view that, there are no colors in the external world, or more precisely, that physical bodies do not have the color that we ordinarily and unreflectively take the bodies to have. Colors are properties that make themselves manifest in our perceptions.

3 Color Dispositionalism

This is the view that colors are dispositional properties; powers to appear in distinctive ways to perceivers (of the right kind), in the right kind of circumstances; i.e. to cause experiences of an appropriate kind in these circumstances. Because they involve responses on the part of color-perceivers, such theories are often called 'subjectivist'. Subjectivism is the view in which colors are sensations, psychological properties of visual experiences, mental properties, representations constructions of the brains, and properties of the brain.

4 Color Relationalism

Averill offered an account according to which colors of bodies are relational properties. Cohen holds that Color Relationalism is the metaphysical thesis that colors are relational properties of a certain sort – relational with respect to perceivers and circumstances of viewing.

5 Action Based Theories

Here colors are taken to be dependent, in part, on the perceiver and so are not intrinsic properties of a perceiver – independent world. Color is a relational property of the environment, connecting the environment with the perceiver. A particular color or shade is equivalent to having a particular spectral reflectance, illuminance, or emittance that looks that color to a particular perceiver in specific viewing conditions.

All above theories essentially refer to the perceived color. The Objectivism also confines to the surface quality of the object and does not refer to the property of the matter in a fundamental way. In Jain metaphysics color is one of the fundamental and essential identifying attribute possessed by all parts of matter, including the smallest constituent paramanu. Color is objective property of matter, and just not a surface quality; it is independent of the perceiver, the light source and other surrounding factors.

Scientific View of Color Vision and Perception

Scientifically, perception of color in humans derives from the ability of the fine structures of the eyes to distinguish (usually three) differently filtered analyses of a view [3]. A surface that diffusely reflects all wavelengths equally is perceived as white, while a dull black surface absorbs all wavelengths and does not reflect. A "red" apple does not give off "red light', and it is misleading to think of things that we see, or of light itself, as objectively colored at all. Rather, the apple simply absorbs light of various wavelengths shining on it to different degrees, in such a way that the unabsorbed light, which it reflects, is perceived as red. An apple is perceived to be red only because normal human color vision perceives light with different mixes of wavelength differently – and we have language to describe that difference.

Most light sources are not pure spectral sources; rather they are created from mixtures of various wavelengths and intensities of light. To the human eye, however, there is a wide class of mixed – spectrum light that is perceived the same as a pure spectral color. An apple, which is perceived as red with spectral sources, may be perceived to have a different color with a light source, which is at variance with spectral source.

Although Aristotle and other ancient scientists speculated on the nature of light and color vision, it was not until Newton that light was correctly identified as the source of color sensation. Goethe studied the theory of colors, and in 1801 Thomas Young proposed his tri chromatic theory, which was later, refined by Hermann von Helmhotz. That theory was confirmed in 1960s. In 1931, an international group of experts called the Commission International d Eclairage (CIE) developed a mathematical color model. The premise used by the CIE is that color is the combination of three things a light source, an object, and an observer.

A light wave can be analyzed as a superposition of sine waves, each of which has a specific frequency and wavelength. Electromagnetic radiation is a mixture of radiation of different wavelengths and intensities. When this radiation has a wavelength inside the human visibility range (approximately from 380 nm to 740 nm), it is known as light within the (human) visible spectrum. The light's spectrum records each wavelength's intensity. The full spectrum of the incoming radiation from an object determines the visual appearance of that object, including its perceived color. The intensity of a spectral color may alter its perception considerably. The colors of the visible light spectrum are red, orange, yellow, green, cyan, blue and violet. In addition to these spectral colors there are many color perceptions that by definition cannot be pure spectral colors. Some example of necessarily non-spectral colors is the achromatic colors (black, gray and white) and others color such as pink, tan and magenta. The perception of color is influenced by biology, long-term history of the observer, and also short-term effects such as color nearby.

The retina of the human eye contains three different types of color receptor cells or cones. (i) The S-cones, called short – wavelength cones are most responsive to light that we perceive as violet, with wavelengths around 420 nm, (ii) The L-cones, called long wavelength cones, are most sensitive to light we perceive as yellowish green with wavelengths around 564 nm, and (iii) The M-cones, the middle wavelength cones, are most sensitive to light perceived as green, with wavelengths around 534 nm. The sensitivity curves of the cones are roughly bell-shaped, and overlap considerably. The incoming signal spectrum is thus reduced by the eye to three values, sometimes called tri stimulus values, representing the intensity of the response of each of the cone types. The set of all possible tri stimulus values determine the human color space.

Herring [4] proposed the Opponent-Process Theory. It postulates computational mechanisms in the visual system to explain how the outputs of these cones lead to the expressions. According to this theory, the outputs of the three cone-types are transformed into two opponent chromatic signals and one non-opponent achromatic signal. It is thought there are pairs of opponent information channels, where the activity in one channel inhibits activity in an opponent channel. The pairs of channels are supposed to be linked to ‘red/green’, and to ‘blue/yellow responses’ respectively. Letting the cone outputs for the long, medium and short wave cones to L, M, and S, the red-green signal is (L-M), the yellow-blue signal is {(L+M) – S}, and the achromatic signal is (L+M). Concentrating on the two chromatic signals, if (L-M) > 0 then the red-green signal produces a ‘red response’, and a ‘green response’ if (L-M) < 0. Similarly, the yellow-blue signal produces a ‘yellow-response’ if {(L+M) – S} > 0 and a ‘blue-response’ if {(L+M) – S} < 0. With such a theory, we seem to have a natural explanation for how we have say experiences of unique red, unique green, unique blue, unique yellow. It also explains why we have experience of bluish-reds, and yellowish-reds, but not greenish-reds.

It should be borne in mind that the theory described above has the status of a simplified model. Finding solid neurophysiologic evidence confirming the theory is proving difficult. It has been estimated that humans can distinguish roughly 10 million different colors, although the identification of a specific color is highly subjective, since even the two eyes of a single individual perceive colors slightly differently. A mixture of three colors, red, blue and green, called primaries can generate most human color perceptions.

Jain View

According to Jain metaphysics the qualities of touch, taste, smell and color being objective reality do not depend on the observer. An observer may or may not perceive the object in its true state due to inability or limitation of his sense organs or sensing system but this does not alter the nature of the object. An object is composed of infinite number of *paramanus* and it has all the colors. But when we see the object we do not perceive all the colors. For instance, a parrot has all the colors but we perceive only the green color. This is due to limitation of our sense organ. An observer possessing superlative powers may see all the colors of parrot. In other words, from the absolute point of view the parrot has all the five colors and from practical point of view its color is green. The observer and the object are independent having separate existence and the observer does not influence the nature of the object. Similarly, truly speaking, the grass is not green, it has all the colors. The number of *paramanus* having green color outnumbers the *paramanus* of any other color and therefore we see the grass as green.

In Jain metaphysics light is also matter, a photon is supposed to comprise of infinite number of *paramanus* and therefore has all the five colors [5]. The colors of light are scientifically known to manifest according to their wavelength, other colors also exist but remain un-manifest. When light is incident on an object there occurs interaction between the colors of the object and the color of light and the color perceived by us is the resultant color so produced. Objects in green light look greenish and redish in red light, the natural color of the object remaining the same. A surface exposed to sunlight looks bright and the part in shade looks dark although both parts have the same ‘objective color’. The term ‘objective color’ here means the prominent color of the *paramanus* of the object. The object as mentioned before has *paramanus* of all colors but the number of *paramanus* of a particular color exceeds the number of *paramanus* of any other color. This prominent color is called the objective color of the object.

On the basis of the Jain theory of color, it is clear that the green color of the grass is the color perceived by us (**Cp**), which is created in two steps: firstly, there is interaction of light with the objective color of the grass (**Co**), and secondly, the resultant product interacts with the sensory (optical) apparatus, the eye. Thus the color observed is not a 'mere mind-spinning'. In fact all the three factors-the object, the light and the subject (sensory apparatus)-play an equally important role in the perception of the color. If any one of the three factors gets slightly changed, there would be a corresponding change in the perceived color. Thus, for example, say,

(1) *A* sees *Grass* in *white* light as *Green*, but *A* sees *Rose* in *white* light as *Red*.
(Example of change in object).

(2) *A* sees *Grass* in *white* light as *Green*, but *B* sees *Grass* in *white* light as *Red*,
(Example of change in the observer; B is supposed to be color-blind);

(3) *A* sees *Rose* in *white* light as *Red*, but *A* sees *Rose* in *yellow* light as *Orange*.
(Example of change in light).

Comparison of Scientific View and Jain View

We now compare the two points of views, scientific and Jain, in the light of some known scientific phenomena concerning perception of color.

Raman's Study of Color

Sir C. V. Raman conducted intensive research on the phenomenon of color, Early in the year 1963; Raman commenced a systematic study of the immense array of material available for the study of color in the shape of flowers and foliage of plant world. The aim was to determine by factual observations the relation that exists between the perceived color and the spectral composition of the light reflected by or transmitted through the petals of flowers or the leaves of plants. His findings corroborate the Jain view that it is the internal constitution of the object which is responsible for producing the color [6]. 'It follows that all aspects of vision including the perception of space and form, the perception of luminosity and the perception of color, can only be understood in the terms of the corpuscular concept of the nature of light.' Again, he clearly states: '.... color as seen in daylight is the sensation resulting from the synthesis by the eye of the whole spectrum of radiation falling upon the object and returned to the eye after *scattering or diffusion by the material of which it is composed*.' It is also shown by Raman that the quantity of light too plays an important role in creation of the chromatic sensation. He writes: 'Remarkable changes in our ability to perceive color follow as a result of lowering the level of illumination of the objects under view. The factor which determines the observation of color is the magnitude of the light-flux which reaches the eye of the observer... All objects which are brilliant red in color become black and are practically invisible in dim light. Per contra, all objects which are white in bright light continue to be white in dim light. Thus, we may conclude that according to Raman, the chromatic sensation, the perceived color Cp, depends upon- (i) the energy of light-corpuscles reflected or transmitted by the object, which is ultimately dependent on the **material of the body**, and (ii) the light-flux reaching the observer.

It can, therefore, be said that the material composing the object is the deciding factor in creation of the perceived color. The various colors exhibited by different flowers or the leaves of the plants are attributed to the specific chemical compounds constituting them. This becomes clear from the following statement of T. R. Sheshadri of University of Delhi, who observes in his article on 'C*hemistry of Flower Colors*' [7]: 'Greater contributions to the bright yellow and orange shades of flowers are made by carotenoies. However, there are others equally important. In recent years, the deep colors of flowers of Butea frondosa (Palas), Cosmos sulphureus and others have been found to be due to the presence of Chalkones and a closely relaxed group called aurone....As already mentioned, the most important are the anthocyanins which are responsible for the bright red, blue and intermediate shades... In the study of the coloring matter of flowers, we have been interested in the chemical structure and the large variations it can undergo. The effect of the structural variations on spectral properties has also been followed up just as in the case of all dyes?'

Doppler Effect and Colour

According to Doppler Principle, when there is a relative motion between the observer and the source of any wave motion, the wavelengths of the wave, and hence the color, undergo a change. This relativity of color to motion has been regarded as a fact contradicting the objectivity of color. A. d'Abro, contends [8]: 'we now come to the so-called secondary qualities- color and sound. Here, for instance, is what would commonly be called a red light we apprehend it as red wherever we may be situated, so that, in contrast to the case of apparent shape, it might appear as though we were justified in claiming that the light was really red, i.e., red in an objective world devoid of all observers. But, if now, instead of occupying a succession of various positions at rest with respect to the luminous source, we move forward or recede from the light with sufficient speed, it will change color. Color, when considered from an impersonal objective standpoint, is thus just as indefinite as apparent shape. Can we at least combine these various colors, as perceived by the various observers, into one common color, of which our private perceptions would constitute but different perspectives?' Needless to say, the task is quite impossible. In other words, there exists in the case of color no parallel to the objective cone of classical science, no possibility of speaking of objective color. Color remains private. Here, then, is a first reason for differentiating color from real objective three dimensional shape, or, again, secondary from primary qualities.'

It follows from the foregoing discussion that the change in the color due to the Doppler Effect is actually the change in the perceived color (**Cp**), and not in the objective color (**Co**). The change in the velocity of the observer creates an apparent change in the frequency of the wave-length emitted from the object (source). It is obvious that the function representing sensory apparatus is not independent of the velocity of the observer, and hence, the change in the velocity would produce a corresponding change in the functioning of sensory apparatus, which subsequently, would give rise to change in **Cp**. Thus, it would be wrong to conclude on the basis of Doppler Effect that there exists no objective color. On the contrary, the Doppler Effect corroborates the fact that the change in the color due to the change in the relative velocity of the observer with respect to the object (source) is only a change in the perceived color; the objective color of the object remains unaffected by the velocity of the observer.

Relativity of Color to Gauge

A. d'Abro speaks of change in color with respect to gauge and concludes that nothing like 'color' exists in 'microscopic world'. His argument is as follows: 'Suppose, then, that a green object is placed on the table. The metaphysician who states that colors are realities which would exist in a world devoid of percipients would presumably state that the object's surface was green in its very essence. But it might well happen that, on viewing the surface with a powerful microscope, we should find it to be made of a patch-work of blue and yellow spots and that all appearance of green had vanished. Unless the metaphysician proceeds to ignore the microscopic view entirely, he will be placed in the dilemma of wondering whether the green quality or the yellow-and-blue one is to be ascribed to the object in the real world. Even so, his troubles would not be at an end, for we might conceive of an ultra-microscopic vision compared with which our erstwhile microscopic vision would be macroscopic and so on indefinitely. Now the change in color that accompanies a passage from the macroscopic to the microscopic suggests that changes of equal importance might ensue from each successive passage to the following microscopic view. Indeed, it might be that for organisms whose size was of the order of wave-lengths no color would manifest itself at all. Inasmuch as it would be highly arbitrary to assert that the ultra-microscopic vision is in any way less worthy of consideration than the more usual microscopic vision, it appears to be impossible to ascribe definite colors to existents in a world devoid of all observers....'

The upshot of this discussion is that when the metaphysician speaks of red as inhering in the flower of a geranium, he is making a statement that cannot withstand scientific criticism. Here, A. d'Abro has confused objective color with perceived color. It should be noted that 'green' color of the object viewed without microscope is only the perceived color, which, as we have seen, is not necessarily the same as the objective color. For, the perceived color (**Cp**) is a function of the objective color (**Co**), light and also the sensory apparatus. The change in 'gauge' may produce a corresponding change in the functioning of the sensory apparatus, and consequently the perceived color (**Cp**) may also undergo a change. Thus, if on viewing the green surface with a powerful microscope it looks yellow and blue, it is quite consistent. Also, as assumed by A. d'Abro with a further passage to ultramicroscopic vision, changes in color might ensue; but this change would be only in the 'perceived color', and not in the 'objective color.' Again, it is also possibly true that for organisms whose size was of the order of the wave-lengths of light, no color might manifest itself at all. But this would happen only because light is the only means for perceiving color through optical equipment (eyes). Inability of micro-organisms to perceive color is only subjective one. Hence it would be wrong to conclude that no color exists in a world devoid of all observers. Truly speaking it is the 'chromatic sensation' which does not exist in the world devoid of all observers.

Perception of Color through Cutis

According to some scientific reports, it is found that some people can identify colors with the help of their fingers in stark darkness[1]. Different scientists have explained this phenomenon slightly differently. Dr. R. P. Yotz has put forth the hypothesis that the rate of absorption of colored radiations by the successive layers of the skin is different. Dr. W. L. Macass of Washington University thinks that emissivity of the surfaces of different objects affect our skin differently. He proposes that the surfaces of different colors have different emissivity. Thus, according to him, the 'cutaneous emissivity sensitivity' is responsible for the identification of color by hand or in darkness. In any case, the following two facts become clear in the light of the above phenomenon:

1. The difference in emissivity by different colored surfaces suggests that there exists some objective property in the object which is responsible for difference in emission.
2. Light acts merely as a medium to perceive the color of an object; in absence of light, the object does not become color less, the objective color exists.

1 One such case was reported by British newspapers in November 1962, according to which a Russian girl Rosa Kuleschova belonging to Nisnitagil city of Rural Province used to identify colours with her fingers. The scientific investigation were made by Dr. Isac Goldbers. Another instance was reported by Dr. R. P. Yotz of Bernard College, New York in 1964. According to him, one Mrs. Staneley could identify the colours in stark darkness. Dr. Yotz performed several experiments on Mrs. Staneley, in one of which she with the help of her hand, successfully identified the colours of various papers placed in a light-proof box. In one case reported by Dr. Karl Konnig of Scotland a blind boy could see by his skin, in another interesting case reported by Dr. Guissepi Cailigerus of University of Rome, a Yogi could perceive things with the help of his skin. (The description given here is based on an article published in *Navnīta* (Hindi)-Digest), July, 1967, pp. 28-31.

Conclusions

Color, smell, taste and touch are the fundamental and objective properties of matter and all four are concomitant. The perceived property may be different from the objective property as the process of perception involves media agencies influencing the perception. Perception of color is dependent on the state of the sensing apparatus, the eye, and also the medium light which is essential for vision. All five primary colors exist in the object but only one or a few of them are perceived depending upon the state of the observer. The perceived color is a function of the state of the sensing apparatus of the observer, and the source of light used. Most scientific studies refer to the perceived color and not to the objective color. The Jain proposition of objective color of matter is upheld in the face of discoveries in modern science.

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