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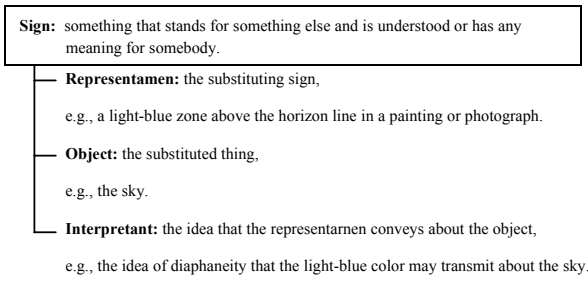
Abstract: The aim of this article is twofold: to make semioticians interested in visual semiotics better acquainted with the very elaborate aspects of color theory, from which they could take models to develop other aspects of visual semiotics, and to make color theorists more familiar with general semiotics, a paradigm that can encompass and organize the whole study of color. General semiotic notions are described and illustrated with examples taken from the domain of color, and an account of some of the advances of color theory is given within the framework of semiotic categories. Aspects such as color semantics, color grammar, color harmony, color combinations, and others, are reviewed. © 1998 John Wiley & Sons, Inc. Col Res Appl, 23, 390-401, 1998

Key words: color theory; semiotics; color grammar; color semantics; color terms; signs; icons; indices; symbols

GENERALITIES ON COLOR AND SEMIOTICS

What can semiotics offer to the science of color in relation to the physical, physiological, and psychological perspectives? The thesis is that semiotics, as a discipline that is at the basis of all biological cognitive systems —human and nonhuman— encompasses and provides the adequate epistemological framework for all the other perspectives.[1] If we consider color as a sign, we are including all the aspects, because a sign is not a previously defined thing, but a consequence of various factors and of the context in which it is taken as such. Color may function as a sign for a physical phenomenon, for a physiological mechanism, or for a psychological association.

Following the conception of Charles S. Peirce,[2,3] a sign is something that stands for something else and that is understood or has some meaning for somebody. A sign is used as a substitute for another thing in order to transmit a concept about it. A *sign* serves to represent or substitute *something,* which may not be present, to some system capable of *interpreting* such substitution. Peirce calls the three categories at play *representamen* —or the sign proper— *object*, and *interpretant*. The representamen is the substituting sign, the object is the substituted thing, and the interpretant is the idea that the representamen transmits about that thing. Let us see a diagram with an example:

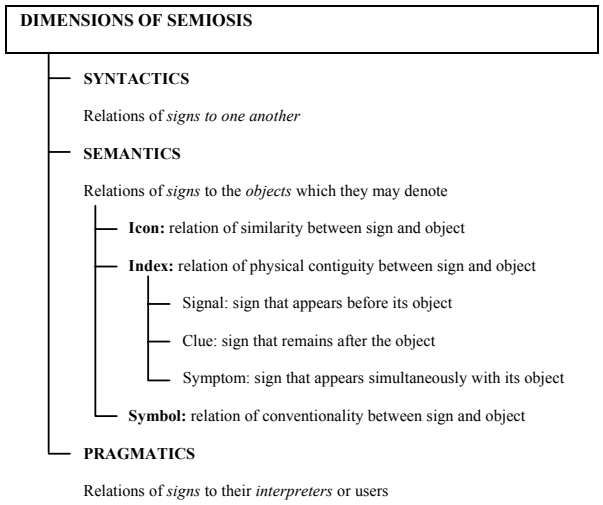


The sign does not substitute the object in its totality, it only covers some aspect of it, and for this reason the produced interpretant never exhausts the possibility of knowing the object. In our example, the elicited meaning is diaphaneity, but the same blue color standing for the sky in the painting could make me think about Rayleigh's experiments that explain how light scattering produces that color of the atmosphere. And these are by no means all the things I can know about the sky by means of its color or by any other sign. The interpretant should not be mistaken for the interpreter, which is the living being or organism that receives the message. The interpretant is also a sign, but we could say that it is a more developed sign than that which gave origin to it.

Charles Morris,[4] employing this triadic conception of the sign but introducing the factor of the interpreter (sometimes considered as a fourth factor, but in general melted with the notion of the interpretant as the agent or living being where

the interpretant sign is produced), has proposed three levels or dimensions of semiosis: (1) the dimension of *syntactics*, where the relations among the signs are considered; (2) the dimension of *semantics*, where the relations between signs and denoted objects are studied; and (3) the dimension of *pragmatics*, where the relations between signs and interpreters are taken into account.

From here on, the organization of the central part of this article is as follows. First, we will see the general syntactic, semantic, and pragmatic aspects of color. Secondly, we will go deeper into the semantic dimension, analyzing the types of signs known as icon, index, and symbol. Within the category of index, a more minute classification will be shown. The diagram below summarizes and defines the basic aspects to be developed in the following sections. The reader can refer to this diagram at any time while reading these sections.



SYNTACTICS OF COLOR

It is in studies on the syntactic level —where the identification of the elementary units, their rules of transformation, and their laws of combination to form larger units with "grammatical" sense is required— that color theory reaches its major achievements. Here we can consider the many color order systems devised, which are more than "dictionaries" of color, the variables for the identification and definition of all possible colors, the laws of color combination and interaction, the harmonies in color groupings, and every aspect that makes it possible to talk of a grammar of color.

Color order systems are like dictionaries, but they have an organization that works not only on the *expression plane* (the level on which the signs are considered in their intrinsic materiality; in a verbal utterance, the phonetic aspect), but also on the *content plane* (the level on which the signs are considered for what they represent; in a verbal utterance, the intended meaning). In the compilation of words in a dictionary there is a similarity on the expression plane among consecutive words, that is, they are lexically and phonetically similar, but their meanings may be completely different. Look at a series of consecutive entries taken from a small dictionary: *accede*, *accelerate*, *accent*, *accept*, *access*. Despite that all five words begin with *acce*, only *accede* and *access* are related by meaning. In color order systems, colors are usually arranged according to their similarities in hue, lightness, and saturation, but this organization also causes the meanings associated with colors to be related. Thus, while lexical dictionaries are merely organized on a syntactic level, color "dictionaries" are also organized on the semantic level.

One could think that this is due to the fact that, while words work mainly as symbols, where the link between the written or spoken expression and the object represented is usually arbitrary and conventional, colors work as icons, thus forming a link between the colors and the objects they represent based on similarity. This is true in some cases: for instance, in any color order system, yellow, orange, and red are close to each other because of a similarity in hue; while blue, turquoise, and green are for the same reason close to each other, being completely apart from yellow, orange, and red. The first group of colors is iconically associated with warmth, the second with coldness. But in many other cases, colors work as symbols as arbitrary and conventional as words, and even, in these cases, their positions in the color order system and their meanings are related.

An order system has also been devised by Jannello for the classification of shapes, in a clear transposition of the models taken from color theory.[5] I applied the same criteria to organize visual textures,[6,7] and the other kind of visual signs called cesias.*[8,9]

For verbal language there are well-established grammatical rules, and, given a verbal statement, one can say if it is grammatically correct or not. It is normally assumed that a grammar of visual language in the same sense is close to impossible. How can one differentiate between grammatically valid or invalid visual "sentences"? asks Saint-Martin.[10] It is not very difficult to demonstrate that this kind of question can be answered affirmatively once one has the appropriate theoretical instruments to describe visual statements. As a matter of fact, any person somewhat accustomed to seeing artistic works intuitively feels, for instance, that a certain configuration or color combination does not belong to the style of a certain artist. Having the tools to explain what kind of spatial and chromatic operations a style consists of, it is easy to determine if a given spatial configuration or color combination meets the rules of that style or not. For one of the elements of visual representations, color, highly developed grammatical rules already

* *Cesia* is the proposed name for the visual sensations aroused by different spatial distributions of light. Cesia involves sensations such as transparency (produced by a regular transmission of light), translucency (diffuse transmission), mirrorlike appearance (regular reflection), matte appearance (diffuse reflection), darkness (absorption of light), and all the intermediate cases among them.

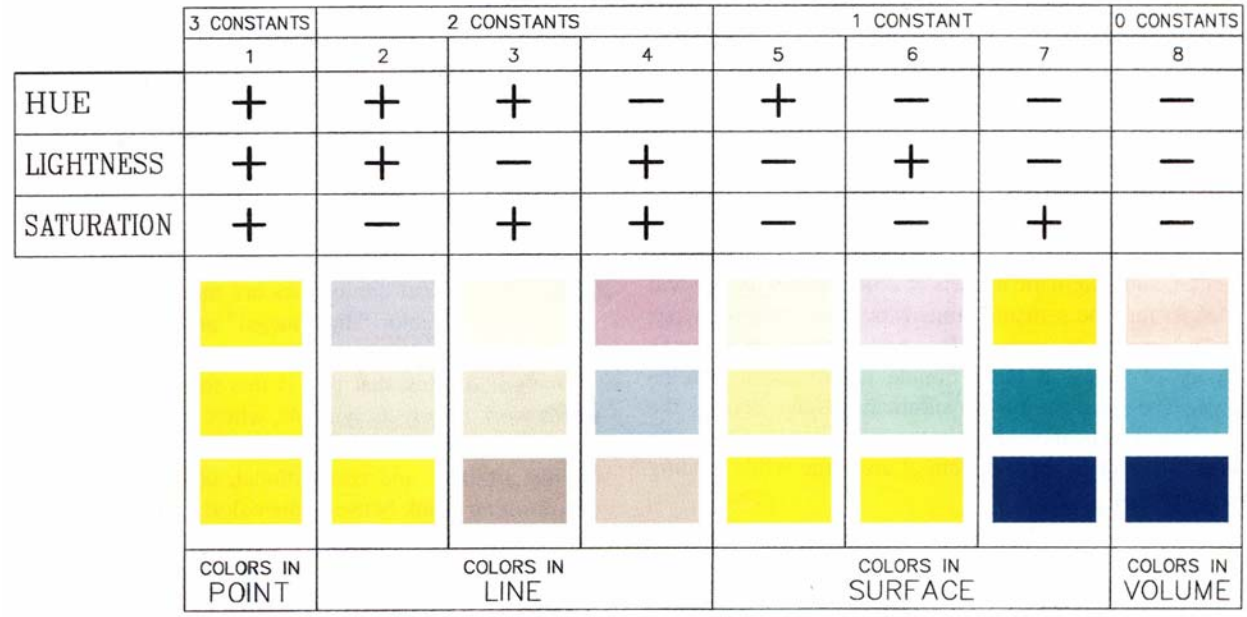


FIG. 1. Matrix of logical relations for color harmonies (after Jannello). The plus sign (+) indicates constancy, and the minus sign (–) variation of the considered dimension. Below each formula is an example of selection of three colors according to it.

exist, which are known as color harmonies and might be compared with the rules that govern musical compositions.

For Wilhelm Ostwald, a notable color theorist and a Nobel Prize winner in chemistry, the only harmonious color combinations are those whose colors hold a direct, simple relationship among their attributes, these being —for him— hue content, black content, and white content. This idea is clearly akin to the traditional concept of musical harmony, where the consonant chords are those whose frequencies are in simple ratios. In the *Color Hannony Manual*, Jacobson, Granville, and Foss[11] explain the twelve principles of harmony according to Ostwald, which can be divided into four groups: harmonies of equidistant gray steps, harmonies of the same hue, harmonies of different hues with equal white and black content, and combinations of the last two.

As early as 1921, Albert Munsell's *Grammar of Color* was published.[12] His nine principles of balance of color can be regarded as genuine grammatical rules. Grammar is largely a product of convention, and so is the grammar of color, depending on aesthetic criteria that may or may not be adhered to. But Munsell's rules of color combinations based on the principle of balance around middle gray may also have a physiological justification: by 1878, Ewald Hering had already explained that in front of a gray stimulus, the consumption and restitution of the optic substance known as visual purple or rhodopsin occur in equal quantities, so that the total mass of this agent remains invariable and the eye is, according to him, in a perfect state of physiological equilibrium.[13] This does not happen when seeing other colors. Munsell's principle of balance of color combinations around middle gray is not an imprecise concept, it is a rule that can be technically verified by placing the colors —with their corresponding relative areas— as sectors of a disk, and making it spin to produce the optical mixture.

Johannes Itten,[14] like his master Adolf Hölzel, describes seven principles of contrast of color, as "the fundamental resource of color design". They are: contrast of hue, light-dark contrast, cold-warm contrast, complementary contrast, simultaneous contrast (already studied by Chevreul[15] in 1839), contrast of saturation, and contrast of extension. One may agree or disagree with these principles. We are merely pointing out that, if they deserve attention, their study should be framed within color syntactics.

César Jannello used a table of logical relations based on the possibilities of constancy and variation of each color attribute: hue, lightness, and saturation (Fig. 1). He also applied this model to the evaluation of harmonies in the selection of shapes,[16] in an example of how a model taken from color theory can be applied to other kinds of visual signs. The same model can be used for the harmonies of visual textures[17] and cesias.[18]

The goal of any grammar is to establish the limits between correct and incorrect expressions of a language, so that communication is possible by avoiding nonsense statements. But all this relies on conventions. On what bases can a color composition be correct or incorrect? Let us answer with an example. In most paintings by Raphael, one finds an equilibrium among the areas occupied by the three main hues: red, blue, and yellow. And it is possible to point out this fact as a general feature of his style. Then, if one finds a color composition that fails to follow that rule, one can say that, in terms of the "grammar" of Raphael, that composition is incorrect. But the grammar of color is not only a matter of aesthetics. It is also important in everyday life. Color combinations that do not follow the accepted conventions fail to communicate the intended message. If colors other than green, yellow, and red were applied in traffic lights without previous notice, a lot of accidents would

occur because people would not know what to do. In an image with a referential purpose, a change in color relationships due to an illumination different from white light would turn familiar objects into unrecognizable things.

Within the domain of the syntactics of color, besides the possibility of definition of single colors by means of three attributes (whether they are hue/value/chroma, hue/lightness/saturation, hue content/black content/white content, or hue/blackness/chromaticness, according to different color order systems), there is also the question of what are the abstract and logical possibilities that govern color combinations and color mixture. In this regard, for two-color combinations, we can point out three possible cases: (1) that one color is applied over and inside another (interiority); (2) that both colors partially overlap each other (overlapping); and (3) that they are juxtaposed one beside the other (juxtaposition). The possibility of both colors being some distance apart is not considered, because in this case a third color appears, the one filling the separation.

Whether we are dealing with color-light or color-pigment, and whether we are mixing colors or combining opaque color surfaces that do not mix together, these three possibilities produce different effects. For instance, if over an area of a colored filter *A* another piece of colored filter *B* is set in relation of interiority, the outcome is two colors: color *A* and a new color, *C*, which is the subtractive mixture of *A* and *B*, color *B* being missed; but if instead of the relation of interiority we have an overlapping, the result is three colors: *A*, *B*, and *C*. These combinations with their results are shown in Fig. 2. Exactly the same happens with transparent inks, watercolors, and the like. Similar situations arise also when *A* and *B* are colored lights, but color *C* is, in this case, the result of additive syntheses. The situations are quite different with opaque color surfaces; in all three cases, no new color *C* appears.

To all this, we have to add that, in the three situations — interiority, overlapping, and juxtaposition— phenomena of simultaneous contrast occur, so that, in reality, if we started with isolated colors *A* and *B*, the perceptual result of the combination would be —apart from the cases in which color *C* appears— A_1 and B_1, each being tinged with the complementary color of the other or with the other color, according to the principles of simultaneous contrast developed by Ann Burge,[19] after Chevreul.[15]

Now, if we are dealing with the combination of colors having relatively small areas to be perceived individually, additive syntheses occur when they are in juxtaposition, as with the pointillist technique of painting or with color TV, but mixed syntheses occur, both subtractive and additive, if they overlap, as in the case of color printing.

SEMANTICS OF COLOR

In the dimension of semantics, where the signs are considered in their capacity to represent or signify other things, to transmit information or concepts that are beyond the signs themselves, a considerable amount of research has also been done in the domain of color. A key word to this aspect is

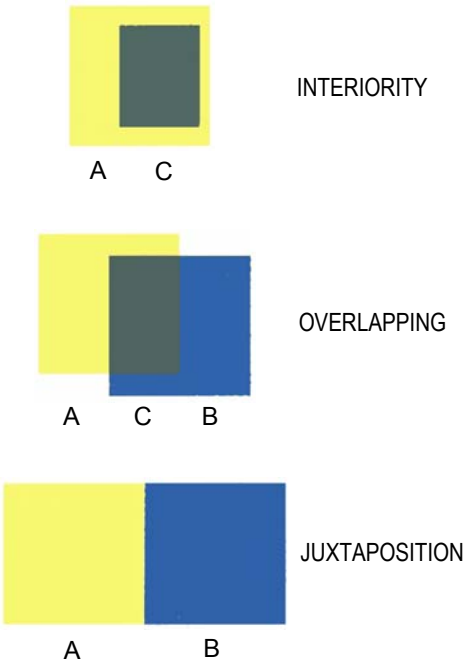


FIG. 2. Logical possibilities for the spatial combination of two colors and their subtractive mixture.

substitution, i.e., color is considered as a sign that may substitute other things. Here, the relations between colors and what they can represent, the codes and associations established through colors, and the way color meanings change according to the context of appearance and in relation to human factors such as culture, age, sex, are explored.

Anders Hård, Lars Sivik, and Charles Taft, from the Swedish Color Institute and the University of Gothenburg, have been researching the meanings of color combinations. Their descriptive model uses the Natural Color System as a basis. These studies "literally mapped the world of color with respect to how associations to various words systematically vary across different parts of the color world". They selected 130 words by a semantic differential scaling method, and the subjects judged color images as "to how well the different word went with the color composition in question". The main purpose was "to obtain a small number of variables that would be reasonably representative of all color describing variables".[20] With these methods, they studied the stability and variability of color-meaning associations across time and cultures.

Kobayashi *et al.*, from the Nippon Color and Design Research Institute, have devised a method to classify single colors or three-color combinations by their associated images. Through the analysis using the axes warm/cool, soft/hard, and clear/grayish as coordinates, they can plot climatic and cultural differences in color semantics.[21] Recently, they

have extended the color image scale to include five-color combinations.[22]

In a latter section, when dealing with the symbolic function of color, we will have the opportunity to mention some other research in the domain of color semantics.

PRAGMATICS OF COLOR

Some aspects of the pragmatic dimension of color have also been investigated. In this case, the relations existing among signs and their interpreters or users are taken into account. Among the topics that can enter this level of inquiry, we can consider: the rules by which colors are used as signs, the functioning of color in the natural and cultural environment, the way organisms identify colors for survival and their importance to food gathering, the physiological and psychological effects of color and its contribution to man's well-being, and the influence of color on behavior. As a way of illustration, we will mention just three examples of research made in this specific field.

Maurice Déribéré has written a book to analyze color in relation to human activities.[23] He describes, for instance, the way colors are used to increase workers' productivity in factories.

The book by Jack Hailman gives many examples of how color acts on animal behavior. We can see that in such activities as intimidation, appeasement, mate-attraction, mate-choice, sexual preparation and intercourse, and parental care, color signs are often used by animals to obtain certain benefits.[24]

Pretorius and Molnar studied the effect of color on lexical comprehension. A curious finding is that "black on white and white on black assisted the highest recall" of information, but green on black —the standard colors for texts in old PC displays— produced an improved comprehension.[25]

COLOR AS A SIGN

So far, we have assumed that colors can function as signs. Taking the notion of sign again, the question would be: is a color able to represent something that stands outside itself? In other words, does red only imply redness or can it be associated with other concepts? We do not need to make a long argument to see that colors do function as signs, and that by means of colors many things can be represented that are alien to them. The previous sections have shown some different ways in which colors represent different things. Without going further, we can realize that often we remember something, and we identify it through a color. When we want to allude to a particular garment, we generally take color as the most salient of the signs we could choose to describe it (ranging from its material to its fabric, some characteristics of its shape or its texture). In this way, for example, instead of speaking of the "woolen sweater," or "the crocheted one," or "the one with the round neckline," or "the one with a checkered pattern," we usually choose to say, "the green sweater." Even if sometimes various kinds of signs are used together, each one making reference to some particularity, the chromatic signs are almost never absent. It would seem that color generally imprints on memory in a more vivid manner than other kinds of signs.

On the other hand, the associations aroused by colors, such as those of relating green with envy, red with passion, black with death, yellow with cowardice, blue with loyalty, are very well known. Of course, those associations totally depend on the social and cultural context, but this does not invalidate the fact that colors are effectively functioning as signs, that there are processes in which colors signify different things.

Magariños de Morentin sets out the semiotic function of color when he says:

> The study of color as carrier of the semiotic function is different from the psychophysical or neurophysiological study in that while the latter identify and analyze color by its characteristics mechanically measurable and dependent on physical circumstances of the subject or of the environment, the semiotic focus considers color as an element objectively *apt to substitute* entities of another universe, and to be organized in meaningful sets.[26]

The simplest substitution is the one by which color allows us to differentiate objects: a ripe fruit is distinguished from an unripe one by its color. Color is what constitutes our visual world; the objects are seen because of borders between them, and these borders consist of tonal differences alone. It is only where a color ends and another begins that we perceive a border. Thus, color performs a highly informative function; without it we would be practically unable to move in the world safely, as happens to the blind.

Color is a sign capable of indicating certain physical properties, as well as the chemical composition of materials. Astronomers can know what kind of matter a distant star or planet —or the atmosphere surrounding them— is mainly made of by means of the spectral analysis of the light coming from that planet or star. Sometimes, for an organism, color can be the difference between life and death: the animal that is capable of camouflaging by adopting the same colors as the surroundings is not seen by its predator. This does not mean that the predator literally "does not see" the possible prey —it may happen that his eyes are actually directed towards him— but he is not able to differentiate the prey from the background; instead he sees it as a part and prolongation of the surroundings. Magariños relates this fact with the idea that, at a first stage of the evolutionary development, the object and its color were one thing from the cognitive point of view; it was the human being who, along with his discovery of language, also discovered color, separating it from the thing.

> Perhaps blood and clay have been the first colors; this means that when they counted as colors they ceased to count as blood and clay. Man had acquired the faculty of considering *things* on the one hand, and the *colors* of things on the other; he had reached the possibility of

duplicating the universe (as he also duplicated it with words . . .).[27]

Therefore, it is in separation from the thing that color is constituted as a sign.

In addition to the important informative function that, in general, color has in nature, there is also the aesthetic function it has in human society, where it is used as an element for the formal composition and the creation of visual harmony in the inhabitable environment.

Color is also an instrument of marketing. It can be used as a sign to represent desirable values of products for a certain group of consumers, values that can be, for instance, prestige, durability, utility. Fashion, as regards color in clothing, goods, and products for consumption, responds to collective transformations, whether they be natural or induced, of the values that colors represent.*

Summing up, everything able to represent any other thing is a sign, as has already been said. Now, what kind of signs can colors be? Do they work in the same way or can they be involved in different modalities of semiosis? In order to analyze this question, we should see first what kinds of signs can be considered in general, that is to say, how signs are usually classified.

There are various types of classifications of signs according to the criteria adopted to make them. One criterion may consist in classifying signs according to the physical channel by which they are transmitted from the source, and/or the sensory channel by which they reach their destination. In the first case, we can have acoustic, thermal, luminous signs, etc.; in the second case, auditory, olfactory, visual, taste, and touch signs. We can clearly see that, in this classification, color is found within luminous and visual signs.

Another kind of classification may be according to the relations between signs and the objects they refer to. Here we come, as we have seen, to the semantic dimension of semiosis, and we can have the classes of signs known as icon, index, and symbol. An *icon* is a sign that refers to its object because of some similarity with it. An *index* is a sign that refers to its object by being necessarily linked with it, because of a contiguity or physical relation with it. A *symbol* is a sign that refers to its object by virtue of some established convention. Therefore, the icon implies the notion of similarity or resemblance, the index the notion of contiguity, and the symbol the notion of conventionality. Can colors work as icons, indices, and symbols? Let us analyze each of these cases.

ICONICITY IN COLOR

When the assignment of meanings to colors is made by psychological associations, the relationships are often based on similarities, as is the case with the association of oranges, reds, and yellows with fire, sun, and heat. It is due to this kind of association, and not because colors would cause any actual difference in temperature, that such colors are typified as warm colors, while blues and green-blues are regarded as cold colors.† In these cases, color is working as an iconic sign.

Déribéré informs us of situations and experiments that demonstrate that the sensations of coldness or warmth felt by individuals being in bluish or reddish environments, respectively —sensations that they feel as real ones— are produced regardless of any actual thermal change in the environment or in the body of the individuals; it is, therefore, a purely psychological effect produced by an association.[31]

Peirce mentions the example of a blind man who thought that the color scarlet —of which supposedly he had received a verbal description— would be something similar to the blare of a trumpet.[32] This case specifically shows how a sound can work as a sign, representing a color by means of an iconic association; but just the opposite might also happen. If a deaf man not acquainted with the sound of a trumpet receives a description of it, and, when he sees a color scarlet he associates the color with the description of that sound, then we have the color scarlet working as an icon for the sound of the trumpet. The relation between color and sound is, in general, an iconic one, for it is based on perceptual parallelisms between both phenomena. Of the same type is the association of color and the quality of vowels in language.[33]

Color order systems with an arrangement that responds adequately to the variable of value or luminosity, such as the solid of Pope,[34] when they are divided by a horizontal plane passing through its medium point, keep dark colors —which

* Leonhard Oberascher points out that, according to observations and surveys of color preferences made during a span of twenty years in an area of Germany, a cyclical pattern has been detected in the change of the colors in fashion.[28] Obviously, this is very useful for the manufacturers that want to be able to anticipate future trends. According to this study, a color cycle begins with highly chromatic colors (chromatic phase), followed by darker colors (darkening phase), a transition to brownish colors (brown phase), which then become lighter tending towards the beiges and pastel colors (lighter phase). Light colors become more desaturated to the point that white and grays come to dominate (achromatic phase). After some time, the achromatic colors begin to be used in combination with highly chromatic colors (achromatic-chromatic phase), and with purple tones (purple phase). Finally, the achromatic colors go out, only the chromatic ones remaining, whence a new cycle begins.

† What is known as "color temperature" has no relation with measurement of caloric radiation in colors; it serves as an analogy used to describe the chromaticity of a luminous source. The color temperature of a light source is the temperature to which a black body —or in more precise terms a total radiator— would emit in the visible region radiation of the same chromaticity as the radiation of the light source. The color temperature is measured in Kelvin units and, thus, for instance, the light from the sun corresponds approximately to a color temperature of 6000 K, which means that a total radiator whose temperature is elevated to 6000° would emit light of the same color as the light from the sun. On this subject see, for example, Evans[29] and Optical Society of America.[30] As Evans points out, it is a familiar experience that, if a piece of metal is heated long enough, at a certain moment it will look red; as the temperature rises, it will become orange, yellow, and white, and at higher temperatures it would emit blue light. As can be seen, this even turns out to be the opposite of the purely psychological association that blue is "colder" than red.

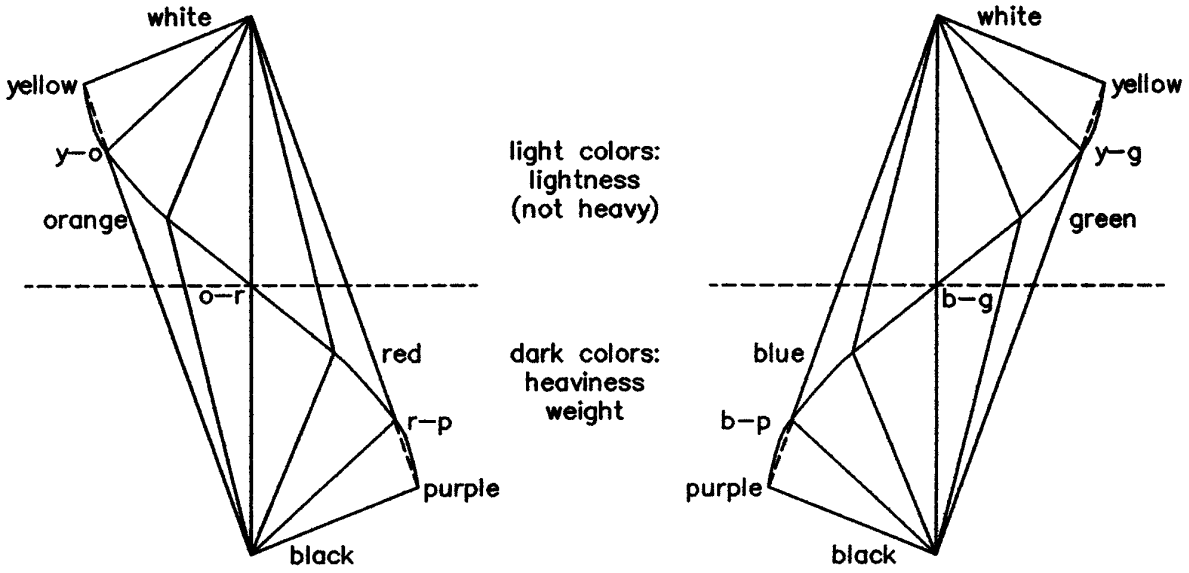


FIG. 3. Two views of Pope's solid of color. Sensations of lightness-heaviness associated with luminous and dark colors, respectively.

are associated with the sensations of heaviness and weight— in the lower sector, and light (not dark) colors — associated with the sensation of lightness (not heaviness)— in the upper sector (Fig. 3). These associations can be considered as iconic ones, because they occur through the perceptual homology by means of which a dark color gives the impression of being more dense, and, therefore, heavier than a light color, which gives the impression of being more dissipated, and, therefore, less heavy, as if the dark color had more concentration of matter than the light color — taking into account that this association works because the physical correlate is made in terms of equality of volume and material.

In this sense, Déribéré describes situations recorded in factories where workers who daily had to manipulate heavy elements painted in dark colors complained about kidney pain, and explains how the problems were solved and the work did not seem so hard when the same elements were painted in light colors.[35]

INDEXICALITY IN COLOR

It is a well-known fact that color is not in the physical matter, nor in the luminous radiation; it is an *image* —now we can say a *sign*— produced in the mind of an organism equipped with a sensory system, vision, that reacts to a certain portion of that radiation. This image or sign is the reproduction that the visual system makes of the radiation coming from the light sources or from the objects reflecting or transmitting that radiation. This is the most primary function as a sign that color performs, that is to say, that function by which color works as a substitute for the physical radiation in order to carry to the brain useful information about the external world. And, in this sense, it is an indexical sign. Why do we say this? Because it is evident that between the sensory image, the sign color, and the physical phenomenon, radiation, there is no similarity or homology of any kind whatsoever, but only a physical connection, a neurophysiological response, built up through millions of years during the evolutionary process of vision systems.[36] This is a question of "brute force", as Peirce says. This mechanism is, for instance, what makes the human visual system react to a radiation of about 700 nanometers of wavelength by producing the color red as a substitutive sign.

An index is a kind of sign that works because between it and what it represents there exists an actual, physical connection that happens in a certain time and space. Due to this, the characteristic of indices is the contiguity between sign and object. A weather-vane allowing us to know the direction in which the wind is blowing is an indexical sign, because the position in which it stands has been caused directly by what it is representing, say, the direction of the wind. Similarly, the fact that the yellowish color of a person's skin is taken as a sign of illness is established by an indexical connection, for it is the illness itself that has produced that pigmentation of the skin.

Naturally, this has some subtleties, because somebody can make up his face in yellow in order to feign an illness he or she does not suffer from. In this case, the indexical connection does not exist, but the receptor, the person deceived by the trick, thinks it does. The addresser, the person trying to produce the deception by the yellowish color on the skin, is using color as an icon, in order to look like an ill person, while the receptor interprets the sign as an index. The lie exists, because the receptor believes that the illness really exists. Color has always been used with the purpose of occulting, feigning, or deceiving; think about camouflage, where the main role is generally played by color (see, for instance, Luckiesh[37]).

Indexicality is also present when the sign is in a relation of *pars pro toto*.[38] In this sense, we can mention the use of color samples

in commercial transactions and specifications in industry, where a small piece of colored material stands to indicate the desired finishing or appearance of the whole product.

Magariños subclassifies the indexical signs into three types: signals, clues, and symptoms.[39] The *signal* is a sign that appears before its object; for example, when a pedestrian sees the red human figure on a traffic-light, he or she knows that the cars at the crossroad will start moving immediately; the lead-gray of the sky is a signal that it is going to rain. The *clue* is a sign that remains after its object has caused it; for instance, after a liquid has been spilled on a cloth, the dark spot that remains for a certain time is a clue to what happened. The *symptom* is a sign that happens simultaneously with the event that constitutes its object; the reddish color on the cheeks is a sign of embarrassment, shame, or annoyance; when the cause ends, the symptom disappears. The driver of a vehicle is guided by traffic *signals*, which anticipate different situations; the detective is guided by *clues* in order to guess about situations that occurred in the past, and these signs, if they remain in time, can be used as evidence in a trial court; the physician is guided by *symptoms* in order to diagnose an illness affecting a patient. In all these types of indexical signs, color usually performs a primary role.

SYMBOLICITY IN COLOR

A symbol is a sign that has a special relationship with the objects it denotes. This relationship is described by Sebeok:

> *A sign* without either similarity or contiguity, but only *with a conventional link between its signifier and its denotata, and with an intensional class for its designatum, is called a symbol*.[40]

The condition of forming an intensional class, i.e., the class defined by means of their members having the property connoted by the term, is important in order to distinguish clearly between a symbol and a name. Being also conventional, the name "*has an extensional class for its designatum*", extensional class being the one defined "by listing the names of the members, or by pointing to every member successively".[41] In short, the symbol defines universals, while the name refers to particulars.

Meanings are often assigned to colors independently of the object in which the color is seen. For instance, the associations *green* = safety, go, *yellow* = a warning, be careful, *red* = danger, stop, are applied in several situations other than traffic-lights and traffic signs. In the context of football matches — soccer, in some countries— a yellow card means admonition (warning, be careful), while a red one means "stop playing, out of match." In industrial architecture, these meanings are also observed and there is an established code for security colors: *green* = safety, associated with the rectangular shape; *yellow* = possible danger, precaution, associated with the triangular shape; *red* = stop, prohibition, imminent danger, associated with the circular shape, or fire-prevention materials, with the shape of the material.[42]

While some of these examples such as colors in traffic-lights might be regarded as the type of sign defined as signal, for Sebeok a singular sign that "*triggers some reaction on the part of the receiver*",[43] we must remember that signs do not belong definitively to one or another class, but vary according to the context. So, the sign *green* may be a signal in one context but a symbol in another. As Sebeok remarks,

> one must constantly deal with *aspects* of signs: to repeat, a verbal command is very likely to have both a symbol aspect and a signal aspect, and the sign in question will oscillate between the two poles according to the context of its delivery.[44]

An interesting case of arbitrariness and conventionality characteristic of symbols in color meanings is the case of black and white associated with birth and death. In western culture, the pairs are: *white* = birth, baptism, and *black* = death. But, as Arnheim notes, *white* has a double and opposite meaning, the purity and innocence of the beginning of life on one hand, and the emptiness of death on the other.[45] Lack of hue means lack of life. In oriental cultures, *white* definitively means death.

The color purple illustrates a case of an index transformed into symbol. In the past, when purple was very difficult and expensive to obtain, it was the color of royalty. In the Roman Empire, only senators, victorious generals, and the emperor himself were allowed to wear purple. Today, this indexical connection has disappeared, but *purple* still conveys meanings of magnificence, pomp, dignity, nobility, and elevated position. In Spanish, the cardinals' rank in the Roman Catholic Church is still referred to as *purpurado.** The general rule that can be verified is that the repertoire of symbols in a culture grows at the expense of other types of signs, for instance iconic and indexical signs.[46,47] In other words, a sign that in a certain context begins to be taken as an icon (because of a relationship of similarity between it and what it represents), or as an index (because of a real physical connection between it and its object), with time and with its reiterative use becomes a symbol, because habit causes the relationship to be preserved in an arbitrary way, independently of the original connection.

If we look at the arrangement of colors in the chromatic circle† and compare the relative position of hues

* It can be argued that the color of the cardinal's robes is not purple but simply red, or scarlet. At this point it is necessary to clarify that in the antiquity the name "purple" was applied to a great variety of colors around red, going from orange to violet, and even more (there was even a greenish purple!). The word was used more to allude to glossy appearance than to refer to a particular hue.

† The chromatic circle is taken as it is organized in the Natural Color System.[48] This system uses only the color names yellow, red, blue, green, plus white and black if we consider the whole solid. Not to complicate the exposition, I have added the intermediate color names instead of introducing the NCS notation for the other colors.

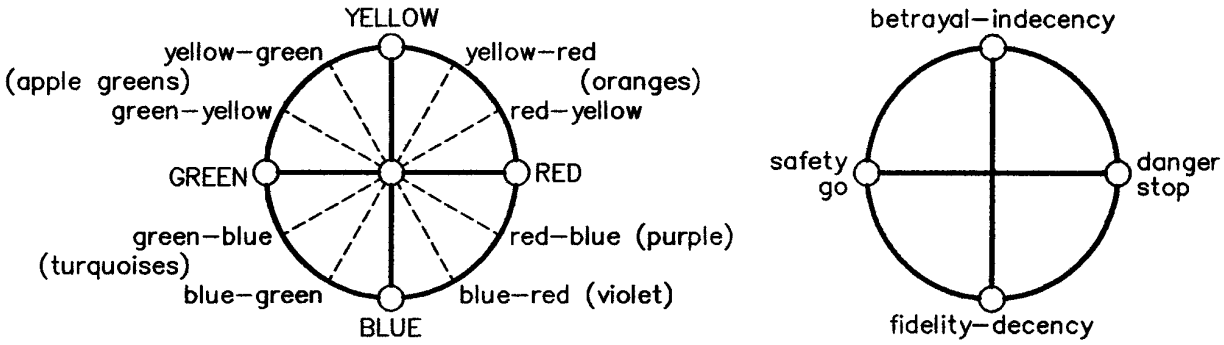


FIG. 4. Color wheel with opposite hue sensations and opposite conventional meanings.

with the meanings assigned to each one, we realize that opposite concepts coincide with opposite hues. This is true of *blue* as a symbol of fidelity and decency, as opposed to *yellow* as a symbol of betrayal and indecency; also with *red* = danger, stop, as opposed to *green* = safety, go (Fig. 4). This is valid not only with concepts bearing symbolic relations with the colors, but also with iconic and indexical links.

César Jannello divided the color wheel into semicircles of warm vs. cool, lucid vs. mysterious, informal vs. formal, calm vs. exciting hues, as shown in Fig. 5 (top). Then he subdivided the semicircles into quarter circles, combining the correspondent adjectives in pairs (Fig. 5, middle), and finally subdivided the circle into eight parts combining the terms in groups of four (Fig. 5, bottom).[49]

John Hutchings is doing an international survey about color in folklore in order to study the symbolism of color in different cultures and traditions, inquiring mainly about the uses of color in clothing, decorations, and food in certain ceremonies such as marriage and mourning, and in family, religious, or public celebrations. By way of illustration, we can mention that, while in the West and in some oriental countries such as Japan the color of the bride's dress is white, the Hindu brides and those of the Han tribe in China wear red, the brides of the Dong tribe in China wear black, and the Chinese brides living in Singapore wear red or pink with gold.[50,51]

As a symbolic element, color is usually a part, along with other aspects such as shape and texture, of more complex visual symbols, for instance flags, pennants, allegories, emblems, coats of arms, trademarks, logos,

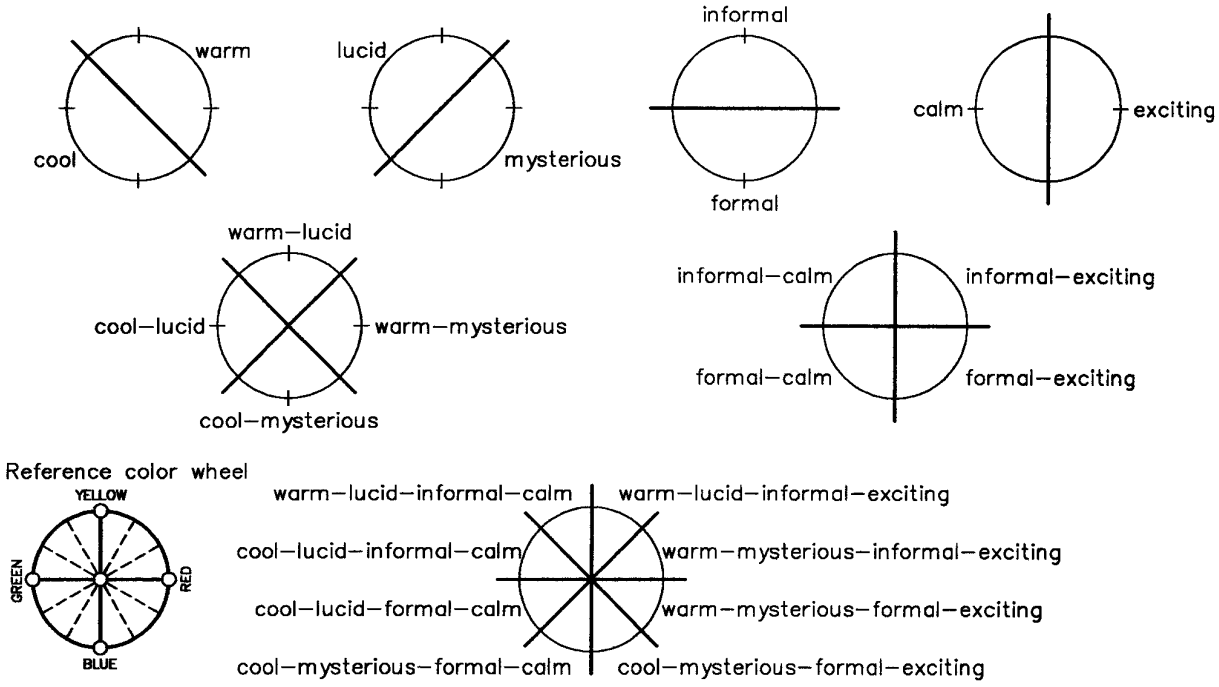


FIG. 5. Jannello's division of the color wheel according to psychological associations.

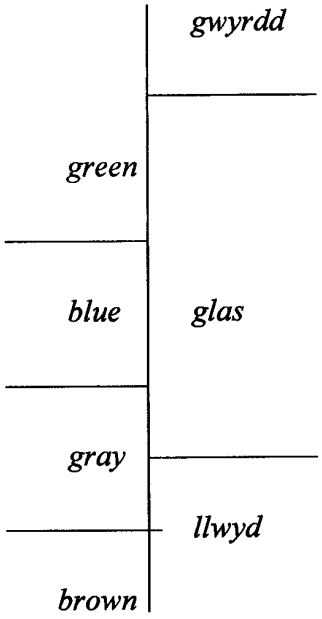
etc. The codes on which these, so to say, more sophisticated symbols are built obey, in general, the codes of the visual elements composing them. In other words, the meaning of the complex symbol is often a kind of cumulative effect of the symbolic meanings of the basic elements (colors, shapes, textures).[52]

COLOR NAMES

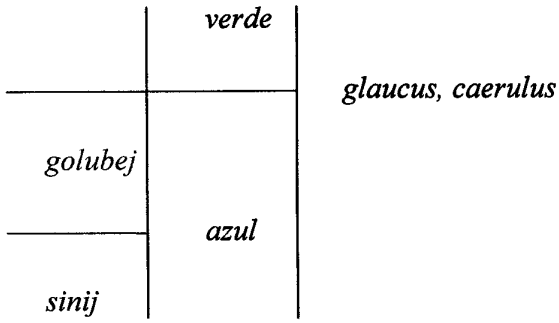
The issue of the names with which colors are designated is of fundamental semiotic concern, because it deals with how the signs of the verbal languages are used to substitute and refer to all that other nonverbal universe constituted by the chromatic signs. In other words, this subject deals with the correspondences between the paradigms of words and colors. In the previous sections, we have seen color as a sign that could refer to other objects; now we will see color as object, and words as signs that refer to it.

As Nancy Hickerson points out, the categorization of the phenomenon of color (which for perception is a continuum) through names that impose divisions on it, is not something so completely natural as to occur in the same way in all cultures and languages, and yet it is not so completely arbitrary as to preclude the existence of common domains and to rule out the possibility of translation from one language to another.[53]

On one hand we can see, as Louis Hjelmslev shows,[54] the lack of coincidence in the domains covered by color names among certain languages, in this example between English and Welsh:



Umberto Eco[55] also mentions the following differences between the Russian culture, Spanish, and the Greek-Roman civilization:



On the other hand, it is also true that some concordances do exist because, as Berlin and Kay have found, there are eleven basic color names that appear in over twenty different languages.[56] Taft and Sivik have made a specific study carrying out surveys with groups of people of different nationalities in order to identify how the assignment of color names is given in each country and to enable comparisons among various nationalities.[57] The results are very easily visualized, because the determined semantic domains have been marked in the color space of the Natural Color System. The observers of the survey identified all colors that according to them could be identified by the color name in question, as well as the colors within that domain that better exemplified the color name, directly by pointing to the samples of the NCS atlas. The survey was first made with groups of people from Croatia and Sweden. The results show that for these two groups, regarding the selected color names yellow, red, blue, green, orange, brown, purple, pink, white, gray, and black —basic terms used by almost all cultures— there is a strong coincidence in the color domains assigned to each name.

Most of the names ordinarily used to designate colors or nuances appeared long ago by analogies with elements of the natural environment: for example, with flowers such as lilac, rose, violet; fruits such as orange, lemon, peach, apricot; plants or their derivatives such as chestnut, cinnamon, maroon (of French origin, a variety of chestnut), mustard, olive, rubicund (from the Latin *rubia*, a plant used to produce a reddish dye, *Rubia tinctorum*), coffee, tobacco, amber (a fossil resin), pastel (from the late Latin *pastellus*, a paste made of herbs); minerals as in ochre (an impure iron ore used as a pigment), cobalt, emerald, jade, ruby, turquoise, cinnabar (artificial mercuric sulfide used as a pigment), brilliant, opal; metals such as steel, bronze, golden, silver; animals, parts of them, or products derived from them such as vermilion (from the Latin *vermis*, *vermiculus*, little worm, from which the color was obtained), crimson (from the old Spanish *cremesín,* and this from the Arabian *qirmiz,* little worm), ivory, beige (term of French origin, which dates back to 1858, designating clothing made of natural undyed wool), cream, pearl, purple (from the Latin *purpura*, a variety of mollusk yielding a dye used in ancient times to make the color), sepia (term of Greek origin, the inky secretion of a cuttlefish); and elements, phenomena, or states of nature as in khaki (term of Persian origin whose meaning is dust), terracotta (in Italian, literally, baked

earth), sand, cerulean (from the Latin *caeruleus*: sky blue), sea-green, ultramarine, green (in old English *grene*, akin to the old term *growan*, to grow; green also means fresh, vigorous, new). Probably, in most cases, no difference was originally made between the object and the color, so that both things constituted one and the same cognitive unit, and it was not until later on that the color name was used making abstraction of the object that had given origin to it. Other colors have been designated with geographical names, because the pigments were obtained in those places, or because some circumstances associated the colors with the places as in the case of sienna, indigo, Nile green, Prussian blue, African brown, bordeaux (Bordeaux is a region of France famous for its wines), magenta (name given by a French chemist who synthesized the pigment in 1859, and who took the word from the name of a town in the zone of Lombardia, Italy, where Napoleon III won a battle[58]). It has also happened, more recently, that some products that became famous have left their names associated to the colors that characterized them, for instance, citröen yellow, coca-cola red. Only a few terms —blue, red, yellow, gray, white, black— seem to be exclusive names of colors without reference to anything in particular.

Now then, beyond a few basic terms, the use of color names has little informative value. Nobody can know with certainty which tone in particular such names as "aged gold," "Aegean blue," "Indian brown," "deep tan," "seal brown," or other fanciful color descriptions, refer to. With the aim of establishing a bridge between this way of designation and the more exact identification through the notations of color order systems, some scholars have undertaken the work of tracking down and classifying color names, rendering them into notations of well-known color systems or locating the terms within color spaces, or, instead, accompanying the list of names with spectrophotometric measurements, or painted or printed samples. We can mention the book published by the U. S. National Bureau of Standards,[59] the Appendices in the books by Munsell,[60] and by Nemcsics,[61] and a dictionary of popular color names in Argentina.[62]

Color terminology has been a long-standing problem. Various authors, on the basis of some color order systems, have developed symbolic notations involving letters and numbers. However, for most users, this is a rather abstract way to identify colors. A recent semantic network developed by Raymond Lauzzana[63] allows for the selection and identification of colors in computer applications by using natural language. The system uses twelve basic color names, four sets of adjectives, and three adverbs to designate more than 7,000 colors.

COLOR THEORY AS A CONTRIBUTION TO VISUAL SEMIOTICS, AND GENERAL SEMIOTICS AS A PARADIGM FOR THE STUDY OF COLOR

What are the benefits of putting color and semiotics together? Indeed, the contributions go in two ways: from color theory to visual semiotics and from general semiotics to the study of color.

Color theory, as it has evolved through the work of many theoreticians, can exhibit, after one looks at it from a semiotic point of view, all the features required for the construction of an extremely elaborate semiotic system. Such a theoretical development offers a model for the elaboration of the semiotics of the other elements of visual perception as well, a paradigm that is more suitable than the models usually imported from linguistics trying to directly apply or transpose the conceptions of verbal semiotics. These attempts to force the visual signs into the models built for the analysis of verbal signs have been criticized recently. Fernande Saint-Martin gives a good account of this.[64]

On the other hand, the semiotic perspective provides the best and most complete epistemological framework for the study of color, because, for living organisms, the important aspect is that color works as a system of signs; and the semiotics of color, which, due to the already mature developments of color theory, may be established as a very sophisticated field in its own right, can be considered as an excellent paradigm, especially in regard to its syntactic features, for the study of the other systems of visual signs, say, shape, texture, cesia, or whatever elements are considered in the analysis of visual perception.

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