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Color Combinations in Capucci's Works
The Experimental Aesthetics of Colors

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Ⅰ. Beyond Physics and Physiology: The Phenomenology of Colors

If we are to analyze certain chromatic phenomena, we must first know what "color" is; we must identify its essential characteristics in an effort to achieve a more rational comprehension of visual phenomena in general. What is difficult for most observers to grasp is that seeing colors is no different than seeing shapes. Indeed, all aspects of the objects in the world surrounding us-shape, size, distance, movement, as well as color--are seen via our perceptual system. The physiological mechanisms leading to the perception of the world around us do not differ in terms of their subjectivity: color is no more subjective than shape or size are, and although both shape and size are subjective, they somehow seem highly objective, independent, and external to us. The particular aspect of reality that concerns how color appears to us is not an illusory one, but an incontrovertible fact underlying phenomenology. The study of color is, above all, a description of how we see it, and researchers formulate their explanations of chromatic phenomena by investigating fundamental relations that can account for various effects described within the describable world.

1. The Structure and Development of Relations Between Color and Physiology-Physics

Any description of the relations that give rise to the perception of color must first be conducted from an anatomical-physiological perspective, and it is primarily physiologists who study the physiological activity that corresponds to the colors we

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see. Therefore, their results are essentially hypothetical, in the sense that physiologists do not make assertions that describe what we see, but they associate what we see with some type of receptor or nerve activity in our visual system. For example, one early-now widely accepted-theory links color perception to the activity of various photoreceptors in the retina. As is well-known, there are four types of retina receptor cells (one type of rods and three types of cones) that respond differently to varying wavelengths of electromagnetic radiation, and a perceived color depends on the activation pattern of these receptors. A second theory highlights how our perception of color depends on two types of "opposing" neural pathways: a particular hue or its opposite hue will be seen in function of which of two pathways is either stimulated or inhibited, such that there are four unique, opposing hues possible. The link between perceived color and underlying neural activity is genetically determined: the chromatic difference between yellow and blue does not depend on our learning or culture but on our biological structure.

It is also possible to study another type of relation determining color perceptionan ecologically important one--i.e., the relation existing between the physical characteristics of stimulation and their corresponding psychological aspects. Even in the simplest of conditions, perceived color depends on the complex spectral, temporal, and spatial characteristics of electromagnetic radiation acting on the eye. In fact, the field of Psychophysics studies the patterns of physical stimulation that correspond to the psychological aspects of color perception. At the same time, however, although many and important correlations have been identified, it is acknowledged that there is not always a one-to-one correspondence between the two dimensions. Indeed, different colors can correspond to the same physiological stimulation (a phenomenon often referred to as "illusion" We cite Mach's book and Gilchrist's effects as prime examples.), and a different set of physical stimuli can correspond to perception of the same color (a well-documented phenomenon known as "metamerism").

To state that the perception of color depends on a network of relations involving both the anatomical-physiological aspects of the visual system and the physical aspects of stimuli does not necessarily mean that these relations are fixed over time. They develop, rather, according to well-known laws, in function of interaction between our biological-genetic structure and the environment.

2. Learned Phenomenal Relations

Just like many other aspects of perception, color is determined not only by patterns of relations at the peripheral-receptor level (as previously illustrated), but also by relations that are established among elements found only at higher levels, e.g., figure-ground relations. Other things being equal, a color will look one way when seen on its own--isolated from its context, and it will look different when seen in a figure; and once again, it will look different when appearing in the background. Hence, in famous examples of figure-ground reversibility (e.g., Rubin's "goblet" and two "faces", 1915), the same area appears to change color along with its figural role. Similarly, certain surfaces change both their chromatic appearance and their appearance of illumination merely by our *seeing them* distributed differently in space (e.g., Mach's book). The observer's attitude plays a special role in these cases of reversibility; in fact, a subjective attitude can voluntarily change the results (with varying degrees of difficulty). Just as we can freely choose to modify the relations our perceptual system takes into consideration (e.g., the frame of reference a detail is seen as pertaining to--and therefore, what colors result from it), so can experience, learning, and general culture bias the sets of relations upon which our perception bases a chromatic result. In spite of the general consensus that knowledge, memory, inferential processes, etc··· somehow do influence perception--and including therefore, the perception of color--these cognitive factors are not considered decisive, but rather quite limited. Indeed, past experience acts a factor in conditions that are already structured to enable it. Hence, one crucial task is to discover if it is possible to distinguish chromatic phenomena governed by laws that can be generalized to all people and are therefore innate, from phenomena that depend on learning and culture--or still yet, on individual differences. In any case, our entire discussion here remains strictly within the perceptual sphere: Chromatic changes are *seen*--not thought, remembered, or inferred.

Even phenomena seemingly removed from simple perception, such as aesthetic pleasure evoked by certain chromatic combinations, depend on specific relations among the colors themselves (as will be described in greater detail further on). In this case, the set of relations determining aesthetic pleasure work at higher perceptual levels; more specifically, our visual system considers them relations among colors that have already been identified, i.e., determined by a set of lower relations (receptor-, opposition-, contrast-, and surface illumination relations, etc···). Yet, certain relations are also important in the perception of aesthetic pleasure merely because they are genetically determined, whereas others play a significant role after development, due to perceptual system maturation and accumulated experience-experience in which memory, learning, and general culture coalesce. In fact, (as we shall see) we can assert that there are certain chromatic relations that render colors generally pleasing to all human beings, while there are other combinations involving opposing relations, whose general appreciation depends exclusively on individual culture or personality.

Obviously, if we are to make this assertion we must adequately define exactly what relations between colors are decisive in rendering certain chromatic combinations pleasing or disagreeable. The development of a color system serves precisely the purpose of identifying and codifying the chromatic characteristics that are most relevant to a pre-established purpose. Two of the most well-known and most-used systems are the Munsell and the Natural systems; they are described in detail here below, in order to highlight some of the more distinctive aspects to which color harmony theory refers.

II. The Main Color Systems

1. The Munsell System

Albert Munsell (1905) was an artist (a painter) who worked in the United States at the beginning of the last century. He was dissatisfied with the lack of precision in the color identification methods of his day. He therefore raised the issue of what criteria should form the foundation of a system that would enable long-distance communication about the diverse colors we see, eliminating the need to refer to color samples. More specifically, Munsell was searching for a way to denote various colors in such a way that the symbolization would be objective and universal enough to require no other tools to identify a described color. He thus established a set of procedures that lead to the creation of a system, which is now widespread throughout the world, i.e., the Munsell Color System.

Munsell's main ordering criterion was that of equi-spatiality i.e., perceptual equidistance in his system between consecutive colors. He arranged all identifiable hues around a circle in a uniform sequence. (All human observers can accurately perform this task, with the exception of the color-blind.) He then subdivided the circle in such a way that a) only 100 hues remained, and b) the difference between two adjacent shades was visually equal to the difference between the two adjoining hues. Hence, Munsell's hue numeration essentially followed a decimal code, although the tendency has prevailed to denominate 5 primary hues (R, Y, G, B, and P) and five intermediate hues (YR, GY, BG, PB, RP) with their relative initials and then to specify the decimal position of a particular hue within one of the 10 thereby-identified intervals.

Munsell used the same criterion of equispatiality to order various degrees of gray along the variable of lightness and called this dimension *Value*. His value dimension included decimal values as well, ranging from 0 = black to 10 = white.

Munsell organized a third color dimension by combining the first two criteria: He isolated colors pertaining to a) the same hue and, b) the same lightness, thereby obtaining a set of colors ranging from a maximum and minimum of *chroma*. He then divided them into visually equal steps.

2. The Natural Color System

1) A Historical-Theoretical Introduction

Due to the language in which he wrote his works, Evald Hering (*1878* 1920) remained quite unknown for many years (the first translation of works from German into English is relatively recent--1964). Yet, perhaps it was also due to his dispute with Helmholtz (whose works had been translated into English as early as 1867) that Hering long represented the vision of an underdog in psychology and of its relations with physiology. Nonetheless, it is precisely Hering's perspective that today seems so modern and fascinating. We unfortunately know just a few trivia about him, and yet his phenomenological approach to perception and his ideas on the relations between perception and the physiology of the nervous system are of extreme topicality. Hering's basic approach to color was phenomenological: he would first proceed with an accurate description of what he saw, disregarding explicative theory and underscoring the characteristics of colors as they appear to any observer. It was precisely in this observational and descriptive phase that Hering underscored how the most important quality of colors is that they resemble each other in different respects. In fact, most of the colors we see resemble a certain number of other colors to a certain degree: these colors can be called *mixed* since from a strictly perceptual viewpoint, by observing each one we can see traces, or gradations, of other colors. To make one of any possible number of examples, in the entire range of orange colors, we see hints of red and yellow, but of white and black as well, to obviously quite varying degrees. Few colors resemble no others, and hence these particular hues are called *unique* hues: they resemble only themselves. Based on observation alone, we can isolate six unique hues--white, black, yellow, red, green, and blue--whereas the range of *mixed* colors we can experience is myriad. It is important to note that the concept of resemblance is completely different from the concept of the physical mixture of electromagnetic radiation and that of pigment. Indeed, the products of certain mixtures may not resemble either of the two components at all. For example, we can obtain various yellows--even very bright ones--by mixing light rays that look red and green when isolated. Vice versa, colors that look alike can be obtained by mixing unexpected wavelengths (see Land's experiments, 1977). Thus, for Hering, the physiological problem was to discover what neural mechanisms underlie the phenomenal characteristics of colors as they appear to all observers. His explanations were merely hypothetical and only much later obtained empirical support. Yet, his concept of antagonistic neural processes as physical correlates of the phenomenal antagonism between colors remains a mainstay in Visual science today.

Although Hering did not actually develop a color system, he did specify certain analytical criteria that would later lead to the development of several well-known color systems, such as Ostwald's system and the "Natural" system. Based onour previous discussion, his criteria can be summarized in the identification of six unique--i.e., primary, or basic--hues, which in chromatic hues look like opposites (incompatible with each other). All other colors can resemble two adjacent unique hues as well as white and black; it is the degree of similarity with each unique hue that distinguishes each color and renders it different from the others.

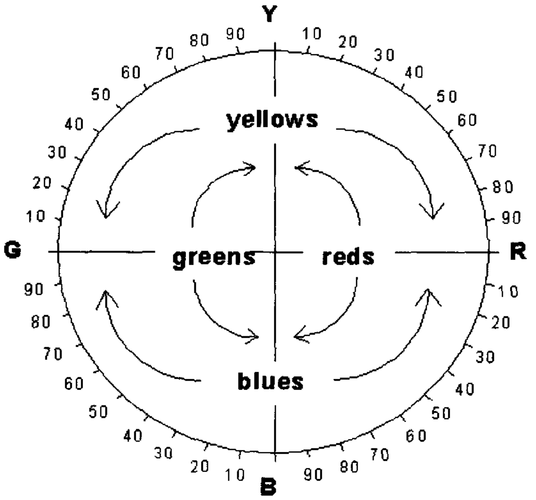
Wilhelm Ostwald (1931) presented his system in the Color Harmony Manual, modeling it on the two main sources of Hering (1920) and Fechner (1838). With a characteristically scientific mentality, Ostwald accepted Fechner's psychophysical research results as valid and applied them to Hering's principles. He thereby obtained a color system in which colors were ordered according to their resemblance to the six unique hues. Moreover, although his subdivision of the various chromatic and achromatic scales kept its basic perceptual significance, it was organized by physical magnitude, based on Fechner's law (which seemed consolidated by then) and the principle of additive complementarity.

However, later developments in psychophysics and mostly, greater awareness of its limits, had diminished the theoretical importance of Ostwald's system, although this reappraisal did not detract from the fascination his manual still holds for those who are familiar with it.

Relatively recently, a famous Swedish architect, Sven Hesselgren (1987) created a purely phenomenal system of colors by taking inspiration from Hering's ideas. Yet, although the resulting system was interesting, it did not completely correspond to its guiding precepts. A group of researchers from the same Swedish school later attempted to concretize Hering's original principles as accurately as possible, conferring a directly usable structure to the color system Hering had called "natural". Given that color combination theory relies on the Natural system as the most adequate analytical instrument and that we use color combination theory further on here to analyze Capucci's works, we shall now give a rather detailed description of the Natural System's most important characteristics here below.

2) The NCS Chromatic Circle

The Natural system obviously cannot differ from any other in the way it orders hues into a closed sequence because (as seen previously) this sequence is fixed and equal for all non color-blind observers. It differs, rather, in how it subdivides the circle into sections that are considered perceptually significant. The basic idea is that unique hues--as defined by Hering, i.e., colors that look only like themselves and no other--have such psychological importance as to be placed in the cardinal points of the circle. In fact, not only do the unique hues predominate as reference points for all others, but they apparently constitute the prototypes of our visual perception; in other words, they are ingrained in our visual system.



B = blue Y = yellow R = red G = green

<fig.1> The color circle

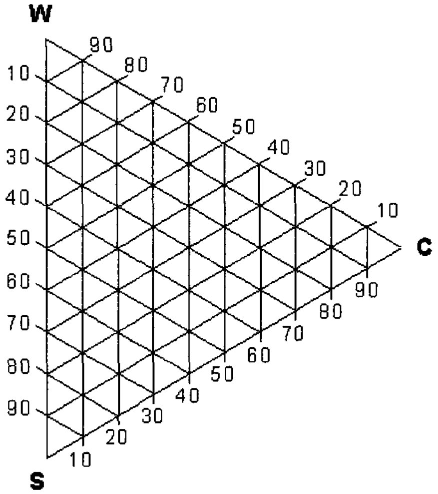
The subdivision of this chromatic circle also takes other perceptual characteristics into account (fig.1). For example, if we observe all colors that in some way look like red, and therefore like red-yellow as well as red-blue, we will not be able to observe even the slightest grading of green in them. Similarly, any color that has some sort of resemblance to green will never look anything like red. By generalizing all possible observations of this type, we can assert that the perception of green in a given color is incompatible with the perception of red in that same color. Indeed, the two colors of red and green are “opposites” or better yet, “antagonists”. We can observe the same type of opposition or antagonism between yellow and blue, but not between white and black. The system thereby identifies four opposing, unique hues plus a pair of non-opposing unique hues, corresponding to black and white (in fact, all grays show a varying degree of resemblance to black and white). The geometric representation considered to be best suited to illustrating the uniqueness and opposition of the four chromatic hues making up the cardinal points of the circle is one in which opposing colors are placed in two different semi-circles, so that all the colors in a semicircle pertain to an area that is clearly different from that of the other semicircle. Hence, the final result is a division of the circle into four equal quadrants, delimited by the four unique hues. In each quadrant there are colors resembling the other two unique hues bordering it. The colors resembling the main unique hue are found in each of the four possible semicircles, and they therefore do not resemble their opposing colors.

This circle subdivision is based on universal phenomenal color characteristics seen by all observers. At the same time, however, it is still conventional, because, while it is particularly efficacious in terms of visual information, other subdivisions are also possible.

3) Various Types of Resemblance (*with chromatic and achromatic hues*)

Once again, when we order colors by examining those belonging to a unique hue and by applying the criterion of resemblance, we obtain the same results for all observers. As previously mentioned, although at times observers may be more hesitant and less certain in their judgements, they tend to find the task of subdividing colors into subgroups of equal hue relatively easy. Each single color of a particular hue differs from other colors of the same hue and is therefore commonly referred to by the technical term *nuance.*

While attempting to work out a satisfactory arrangement for the various nuances pertaining to a single hue, the sole criterion of resemblance does not, at first glance, seem to suffice. Yet, while observers may at first feel awkward with the task, they quite rapidly reach a thoroughly satisfactory result, which seems to be fixed and unmodifiable, in the form of a triangle (fig.2). In other words, all observers tend to arrive at and accept these relative positions of various colors as their most natural ones, and any change in the relative disposition of colors is seen as inaccurate. One procedural difficulty in the process derives from a lack of certain colors in our NCS color samples subdivided by hue. Indeed, there are gaps in how this system's spatial organization represents resemblance relations. In other words, if the geometric distance between colors depends on their degree of resemblance, we should have more samples for certain areas, and there should be more gaps in others. This situation brings to mind Mendelev's ordering of the periodic table of the elements; he maintained that certain gaps in the table corresponded to yet-to-be discovered elements. Similarly, the gaps in our arrangement correspond to colors that are not easily obtained through current production methods-methods conditioned by the requirements that any color produced must be stable over time as well as safe for the environment. The system is therefore apparently expandable in terms of the number of colors it can comprise. At the same time, however, it is logically confined within its external limits for the following reasons….



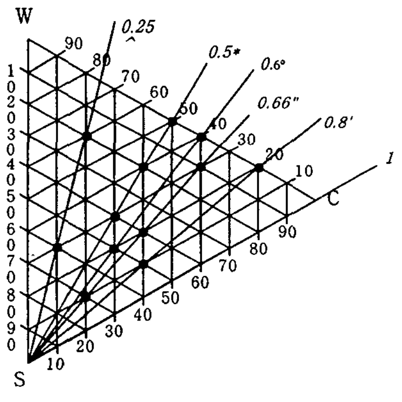
W = white C = chromaticness
S = black (Schwarz)

<fig.2> The nuance triangle

If we analyze the characteristics of the various nuances of a hue, arranged according to their degree of resemblance to that hue, we realize that one area of the obtained spatial distribution includes colors that are very similar to the full hue of chroma. In an another area, colors appear to resemble white to a greater or lesser extent ("pastel" colors), whereas in a third area, they share a certain degree of resemblance to black ("dark" or "deep" colors), and these three areas are contiguous, with gradations flowing from one into another. If we generalize this type of observation, we reach the conclusion that each nuance resembles a) the full hue, b) white, and c) black, to varying degrees. There are no other alternatives: a color resembles another only along these three dimensions. Hence, the spatial structure of this arrangement results in a triangle, with the full hue, white, and black located at the three vertices. If, lastly, we consider any series of nuances that vary only in terms of their resemblance to the full hue and white, we observe that, as their resemblance to white increases, their resemblance to the full hue decreases. We can likewise observe that in a series of colors varying only in terms of their resemblance to white and black (the "grays"), their resemblance to black diminishes their resemblance to white. There obviously can be no colors outside the intervals located at the three vertices. Hence, the system is called a "closed" system. Moreover, on the scale ranging from the full hue to black, a maximum of resemblance to black results in a minimum of resemblance to the full hue and vice versa. The scale thus seems to be a natural interval, where blackness varies from 0 to 100%, and chromaticity varies correspondingly from 100% to 0. It is therefore reasonable to denote each color of this scale with a number indicating its degree of resemblance to the two extremes of the interval. If we extend the same principle to the three colors characterizing the vertices of the triangle, each nuance will be identified by three numbers, each of which denote its resemblance to each of the three vertices.

By following the above-described ordering procedure, we obtain a system in which the main characteristic of colors is that they have gradations--or "veilings", in Hering's terminology--resembling unique hues. We have also seen how, while any color can resemble white and black to a greater or lesser degree, it can also resemble two contiguous (non-opposing) chromatic hues. The aspect of lightness, which plays a crucial role in Munsell's system, does not figure in the Natural system. It is possible to make lightness judgements for each color in the Natural system, but this particular dimension cannot be represented uniformly for all hues. First of all, the lines connecting colors of equal lightness are not parallel, as they are in Munsell's system, but they converge in one point for each plane denoting a single hue. Furthermore, this convergence point is located in different positions in function of different hues. We can therefore assert that although the lightness of colors is an important aspect of their appearance, it is secondary to the other cited characteristics, which can be summarized in terms of the degree of each color's resemblance to six prototypic colors.

Lastly, let us mention the concept of saturation--used so frequently and uncritically by many researchers. Munsell's concept of chroma differs from the Natural System's concept of chromaticness (resemblance to the full color), and both concepts differ from that of saturation. Although saturation is defined rather generically (the relation between quantity of color and white), any accurate formulation of the term should associate this dimension with the way it is measured. Therefore, saturation in the Natural system--it does not exist in Munsell's system, there is only chroma--is *equal to chromaticity, in relation to chromaticity and whiteness taken together, excluding blackness: sat = c / (c + w).*



<fig.3> Lines of equal saturation

It therefore follows as a corollary that blackness (the degree of resemblance to black) does not play a role in determining a color's saturation. Thus, it is not reference to gray, but to white that determines the saturation of a color. In fact, we can plot lines of equal saturation in the nuance triangle (fig.3) and observe that they converge in black.

III. Harmonic Combinations and Pleasing Combinations

We sometimes talk about the "harmony" of colors by using this rather complex term, which usually refers to the overall evaluation of a work. Other times, we more accurately limit ourselves to expressions such as the "pleasantness" or "agreeableness" of chromatic combinations--terms that indicate a more restricted but directly measurable quality of colors. Many theories have been proposed to determine the conditions that are necessary for combined colors to evoke pleasing impressions, but we shall merely sketch them out here, since we shall focus on a more recent theory, which has found promising empirical support and potential for practical application.

Among the various aspects past theories have proposed as important for creating pleasing color combinations, the most well-known is the concept of balance. The term "balance"has been used mostly in the strict sense of gravitational balance (light colors at the top and heavy colors at the bottom). Yet, it is also used in the sense of balance induced by *complementary* colors, therefore as *spatial* balance where: a) the size of an area is inversely proportional to the saturation of its relative color, or b) when two colors are complementary, the size of an area is proportional to the quantity with which each color must be present in an additive mixture making gray. Furthermore, balance has been used to indicate neither too much nor too little *difference* between two colors.

One last factor thought to be important for determining the harmonious combination of different hues was proposed more recently by two nearly contemporary researchers: Mueller (1948) in Switzerland and Abbott (1947) in the United States. The premise for understanding their theoretical position consists in remembering that by observing the electromagnetic scale (e.g., a rainbow), various discriminable hues look differently bright: yellow and green look very bright vs. the darker red and blue. Not only spectrum colors, but all surface colors can be evaluated in terms of the lightness of each hue, and it is therefore just as possible to derive an ordered scale of hues based on their global, primitive, and natural lightness.

Based on this theory, then, a bichromatic combination will show a high degree of aesthetic harmony if the nuances composing it (in technical terms, *corresponding* nuances) have relations of lightness that are similar to the relations between their original hues. This means, for instance, that when we combine a yellow with a red to achieve a pleasing combination, we should choose a lighter yellow (i.e., in the Munsell system, located on a higher Value line) than the red with which we choose to combine it (located on a lower Value line). Conversely, if the relation is reversed, or--technically-speaking *inverted*, the resulting combination is considered disagreeable. Mueller thought that this principle could be used to measure different people's degree of aesthetic sensitivity. He maintained that observers who judged corresponding combinations as harmonious (and vice versa, inverted combinations as disagreeable) could be considered gifted with aesthetic sensitivity, and those who did not would not be considered aesthetically gifted.

1. A Chromatic Combination Theory

1) What the Theory Says
(Relations between Aspects of Whiteness and Blackness)

Werner Spillmann, a student of Mueller's, found that his mentor's theory could not explain how certain corresponding combinations tend to look rather ugly, and conversely, how other inverted combinations tend to look pleasing. At the same time, however, Spillmann did not accept being considered aesthetically insensitive, especially since many other reputable observers shared his very same observations. He therefore proposed a modification of the original theory a modification that included referencing the Natural color system instead of Munsell's system (as Abbot and Mueller had done).

Spillmann's formulation (1983, 1985) can be synthesized as follows: a combination of two colors of a different hue is called "corresponding" when the color of the naturally lighter hue is *whiter and less black* than the color of the naturally darker hue, which must consequently be blacker and less white. An *inverted combination* is one in which the relations of whiteness and blackness are similarly reversed. We thus have two relations that are considered important for the pleasantness of a color combination: relations concerning whiteness and blackness and not just lightness. We can also have a third type of relationship, in which only one of the two relations is inverted and the other is a corresponding relation, i.e., a *partially inverted* combination ("vague inverted" in Spillman's terminology). Hence, there can then be combinations in which a color is *whiter and blacker* than the other color in the pair. According to Spillmann, corresponding combinations look generally look pleasing to all observers making agreeableness judgements. More specifically, corresponding combinations are judged, on average, as the most agreeable, while partially inverted combinations are considered the ugliest. Conversely, inverted combinations--especially those in which the inversion includes lightness as well as whiteness and blackness (and hence a good degree of contrast)tend to look unusual or strange, presenting special qualities that render them disagreeable to some observers and more pleasing to others who like originality.

The Munsell system classified certain *partially inverted* combinations as *corresponding*, and in fact, Spillmann noted thatthese combinations generally look disagreeable. Hence, his theory, which has thus far been supported by a great deal of experimental evidence (da Pos & Fabrizi, 1988; da Pos, 1992, 1995; da Pos & Fossati, 2000), represented an improvement on previous theories, managing to explain apparently discordant instances. It is important to note, lastly, that Spillmann's step forward can be mostly attributed to his use of the Natural system as a reference for the notation of colors a system in which the basic attributes of color (degree of resemblance to six prototypic colors) are more important--perceptually-speaking--than those characterizing other color systems.

2) What the Theory Does Not Say

Spillmann's theory has been tested in numerous experimental studies, but it considers only bi-color combinations in which different hues are present. It therefore makes no assertions about monotone combinations, nor about what hues should be combined to evoke impressions of varying degrees of pleasantness. Other things being equal, monotone combinations are generally less appreciated than two-hued combinations. At the same time, however, there are no solid theories supported by experimental evidence concerning what hues best combine to give the impression of beauty. There is a general consensus, however, concerning one aspect considered essential to the agreeableness of color combinations: two hues must be different enough so as not to create the impression of confusion. Other than that, it is currently not possible to make any further assertions about what hues best combine to create the appearance of beauty.

3) When Colors Share Attributes

Both untrained observers and famed researchers tend to assume that colors resembling each other in certain respects produce particularly pleasing combinations. For example, juxtaposed colors of the same hue or of the same nuance, or even of the same chromaticness, tend to create harmonious effects. This belief is based on the idea--proposed by many authors--that harmony is achieved when there is a balance between unity and diversity and between simplicity and complexity, i.e., when there are common elements that link up and establish a unit, with other characteristics that vary, breaking up the monotony and creating a sense of originality. Nonetheless, there seems to be no empirical evidence for this assertion--mostly due to its lack of specification, whereas the common experience of almost all observers provides substantiation for it.

There is some evidence that in certain situations (da Pos *et al.*, 1995),colors of the same hue and whiteness (or of the same saturation) variable therefore only in chroma and blackness-- look like a single surface color, and their differences are perceived as variations in illumination: one moment the color is seen in light and the next, in shadow. It is no surprise then to find similar pleasing relations of resemblance/ difference in chromatic compositions in which different colors, even different hues, appear to vary in illumination (because they appear to have the same whiteness and to vary in blackness) thereby maintaining the same apparent nuance.

Ⅳ. A Work of Capucci's Examined in Light of Chromatic Combination Theory

1. Method

Our study of the chromatic combinations in a garment is confined here to an analysis of the combination of adjacent colors. The theoretical justification for this choice is that the main chromatic feature of the various areas our visual field can distinguish is determined by variations perceived in transition from one area to another, i.e., near dividing edges. Of course, the simple perception of any color depends on this type of difference in stimulation between two adjacent colors, but the aesthetic effect produced by two colors is also similarly determined by the visible relations between the two adjacent parts. Naturally, a more comprehensive vision of an entire garment integrates these individual aesthetic elements into a higher-level unit, but without the elements losing their distinctiveness.

The first phase of our analysis consisted in defining each color of the Capucci garment in terms of the NCS notation system. We first placed small A9 color samples from the NCS Album on the material of the garment and observed them under natural light. We then attempted to determine the most precise NCS notation possible for the material by making any necessary interpolations among samples with the closest resemblance to each other (table 1, fig.4). This experimental procedure can be even more precise and reliable (not to mention more interesting) if conducted simultaneously by two or more observers.

We then plotted the position of the colors whose relations we wanted to examine on the NCS triangles (fig.5,9). Once the naturally lighter (or darker) hue in a color pair had been identified, we determined the areas of corresponding, inverted, and partially inverted nuances. As seen previously, the chromatic relations of interest mostly concern the resemblance of colors to the three standard references of white, black, and the full hue. We then compared other relations among the various nuances in order to single out any other identities, proximities, commonalities, etc….

Lastly, we attempted to synthesize the identified relations in a comprehensive and meaningful framework.

2. Garment

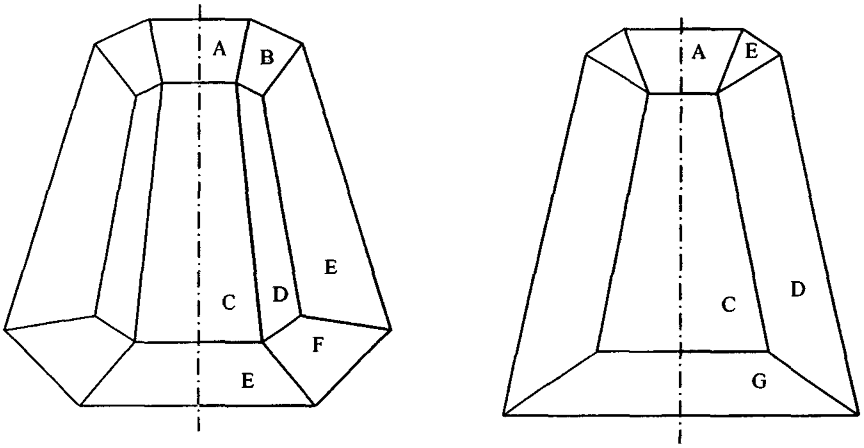
Mondrian *Geometria / donna modern (Trapezi con ali)* Rome, Palazzo Venezia 1987 Collection Parma Catalogue, p. 122 This garment was presented at the Erfurt Triennial exhibition (Thueringen 1991) "Configura und Kunst in Europa": among the 350 European artists participating, Roberto Capucci presented his sculpture in fabric, the only work in this material.

Table 1. Colors used in the Mondrian garment, in NCS system notation.
Description of garment colors and their relations.
Front:

A	00 80 20	Y30R	yellow orange	Bodice
B	30 50 20	B10G	sky-blue	Top wings
C	20 70 10	R20B	lilac	Front center
D	50 40 10	G	green	Side center
E	30 50 20	R50B	light violet	Bottom center
E	30 50 20	R50B	light violet	Wings
F	20 70 10	R	red	Bottom side

Back:

A	00 80 20	Y30R	yellow orange	Bodice
C	20 70 10	R20B	lilac	Back center
D	50 40 10	G	green	Side center
E	30 50 20	R50B	light violet	Back wings
G	50 50 00	R80B	reddish blue	Bottom back

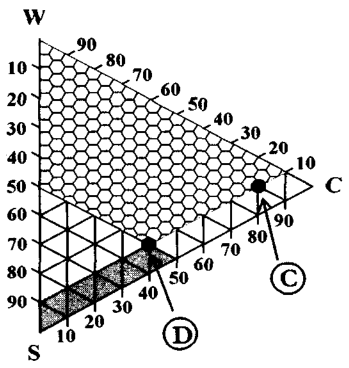


Front

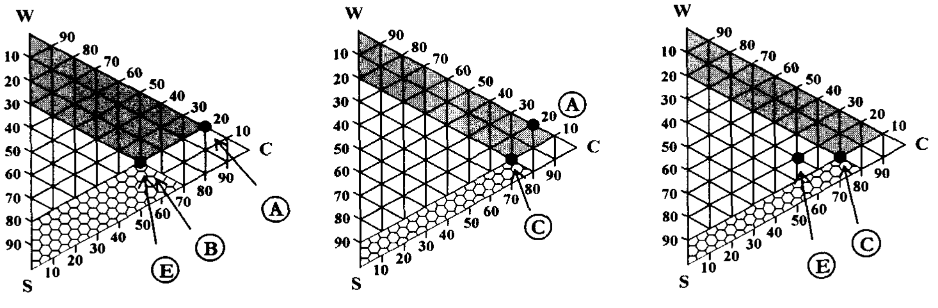
Back

<fig.4> Schematic localization of colors in the garment.

As shown in Figure 5, the three colors of the various parts of the bodice (A, B, and E in Tab. 3) have the same whiteness, and they form corresponding combinations (A/B front, A/E back); moreover, B and E belong to the same nuance. The gray transparent area includes yellow-orange *corresponding* nuances with respect to colors B/E (sky-blue/light violet), while the textured area contains *inverted* nuances.



<fig.5>

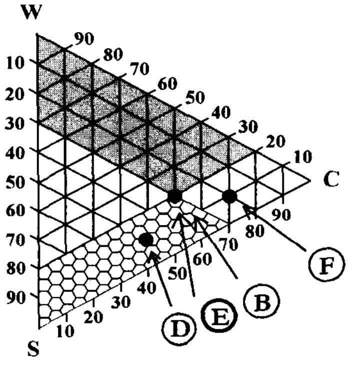


a) b) c)

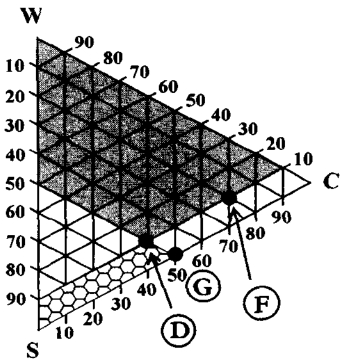
<fig.6>

Figure 6 shows how the front center panel (C) forms: a) an inverted combination with the color of the front side panel (D), b) a corresponding combination with the color of the bodice (A), and c) a partially inverted combination with the color of the bottom front part (E).

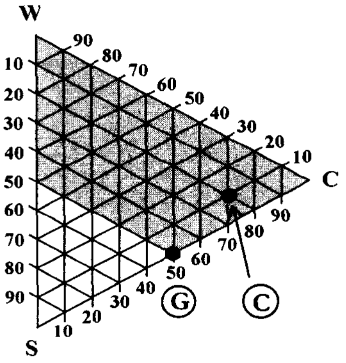
Figure 7: The color of the front wing (E) forms an inverted combination with the color of the side panel (D), a partially inverted combination with the color of the bottom part (F), and it has the same nuance as the top part (B).



<fig.7>



<fig.8> About here



<fig.9> About here

Figure 8 shows how the color of the side panel (D) forms a corresponding combination in the front (F) as well as an inverted combination in the back (G) with the bottom part of the garment.

In Figure 9 we can observe how the color of the back center panel (C) is the same as the one in front, and has the same relations with the adjacent colors, except for the bottom part (G) with which it forms a corresponding combination.

V. Conclusion

The colors in this garment are uniform, not iridescent (except, obviously, in function of the fabric's gloss and therefore of its gradient with respect to the observer and to the light striking it). The number of the colors is limited (7 in all, see Tab.3 and Fig. 3A). The juxtaposition between colors (see the example in Fig. 3B for the bodice and in Fig. 3C for the front) form five corresponding combinations (A/B, A/C, A/E, C/G, D/G), two of which have equal whiteness (A/E) and one of which has equal blackness (G/D). There are also three inverted combinations (C/D, E/D, and D/F), two of which have equal whiteness (C/D and D/F). Lastly, there are two partially inverted combinations (C/E, F/E) at the bottom of the garment.

It is important to note 1) how the colors have a very low whiteness (A, B, and E = 20; C, D, and F = 10; and G = 0), and therefore, a quite high saturation, and 2) that there are two equal nuances (B and E). The corresponding combinations concern the relations of the bodice to the other parts of the garment, whereas the inverted relations are found in the main panels, the side panels, and in the wings. It is precisely this center area of the garment that gives a remarkable sense of chromatic originality, in harmony with the upper part (corresponding combinations with the bodice) and terminating at the bottom with partially inverted combinations, which anchor the garment to the ground and draw the observer's gaze upward.

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