Colour theory: Definition, fields and interrelations

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"Colour theory" is a widespread expression, but its meaning remains unclear due to a lack of discussion on its definition, as it is often interchangeable with "text on colour". In this paper, I will a) propose a definition of colour theory, b) describe three of the main fields where it is used (philosophical, scientific, artistic) and c) discuss how they interact with each other, stressing what they can share but also their own specificity.

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Introduction

Colour theory is an important topic given the great number of existing colour theories, but on which the literature is still rather poor. Within the art field, for instance, colour theory should be an important part of art theories, but a quick survey on textbooks devoted to theories of modern art shows that it is not the case. Most of the time, the content of these textbooks is organised in such a way that it doesn't make it possible to include a chapter on colour, because they display art movements in chronological order [1-2].

Texts on colour might be included, for instance in artists' statements or excerpts from painters' letters, but in many of these textbooks, there is not even a "colour" entry in the index [1, 3-4]. One exception is Barasch's book [5] in which there is a chapter on colour in abstract art. In this case, the author has a special interest for colour [6].

Not surprisingly, colour is still overlooked in art theories. In principle, "colour theory" could help in providing art historical texts on colour, but it is most of the time used in a loose meaning and lacks a good definition on which there could be a consensus. As it often happens with other concepts, we all use that of colour theory without feeling it necessary to define it. So, what exactly is a colour theory?

A first look

It is indeed striking to note that even in books entirely devoted to a review of colour theories, no definition is provided of them. As a starting point, let's begin with the one written by Maurice Elie [7], precisely entitled (in French) *Colours & Theories*. It is an anthology of texts on colour from the Greeks up to the twentieth century. Even though such an anthology is quite helpful, nothing is said about what colour theory is. Why is the definition of colour theory taken for granted? The reason probably lies in the history of this book. Elie is a French philosopher who translated into French the volume of the historic part of Goethe's *Farbenlehre: Materialien zur Geschichte der Farbenlehre* [8]. Goethe is then his point of departure, which he explicitly acknowledges [7 p17], his intention being to extend Goethe's history of colour theories up to the twentieth century. Now if we wonder why this book, dedicated to colour theories, doesn't give any definition of it, the answer probably is that Elie didn't find it necessary to define what he means by "colour theory" because he just wants to complete Goethe's survey of colour theories.

Elie's book presents texts written on colour, organised in chronological order (as did Goethe in his Materials). The third and last chapter contains texts related to artistic movements (German Expressionism, cubism, abstract art, Bauhaus,...), as well as to philosophers (Husserl, Wittgenstein, Merleau-Ponty,...). One section of this chapter is dedicated to "colour theoreticians," and includes John Gage, Josef Albers, Frans Gerritsen and Yves Klein. It is worth examining it more closely, as one could expect this section to explain why these authors are considered as theorists (which implicitly means that the others are not). About Gage, the author chooses to translate a few excerpts from *Colour and Culture* on subtractive colour mixture. As far as Albers is concerned, Elie noted that his book contains many experiments the artist shared with his students, and that he was quite interested in colour interactions and afterimages. Reading the excerpts quoted by Elie, the reader can hardly understand why these authors would be more "theoreticians" of colour than so many others. It turns out, then, that colour theory has no specific meaning for Elie and refers rather to texts on colour.

Other similar anthologies, for sure, consider the excerpts published simply as texts on colour. One, for instance, is entitled *Primary Sources. Selected Writings on Color from Aristotle to Albers* [9]. However, it must be noted that in the index [9 p240], all the authors cited (artists, philosophers, scientists) are referred to under the entry "colour theories". Here again, it seems that "texts on colour" and "colour theories" are interchangeable. A last example: Zelanski and Fisher's book, simply called *Color* in English [10], has been translated into French as *Les Théories de la couleur (Colour Theories)* [11], which corresponds only to Chapter 6 ("Theories of Color Relationships").

What can we draw from this quick survey? There is no general definition of colour theory, which can therefore be understood simply as texts on colour. This remark makes this special issue on colour theory even more necessary.

Definition

In the last section, I indicated that if Elie doesn't give any definition of colour theory, it is because he follows Goethe. More generally, one could suggest that Goethe is probably responsible for the wide diffusion of the expression "colour theory," when referring not only to his own, but also to that of the other authors he gathered in his *Materials* [8]. This would also explain the implicit consensus on what colour theory is or could be. However, a quick semantic discussion should prove useful in order to understand what colour theory means for him. First of all, it is important to stress that the main term he uses is *Die Lehre*. The German title of his seminal book is indeed *Zur Farbenlehere*, which is usually translated as colour theory. For instance, Eastlake's English translation is entitled *Theory of Colours* [12]. Yet, why did Goethe choose the word "*die Lehre*" when "*die Theorie*" was available in German? Interestingly, Goethe also uses "*die Theorie*", but when referring to Newton: "*die Newtonische Theorie*". Why this difference? *Die Lehre* comes from *lehren*, to learn. So, it has more the meaning of a lesson, the learnings from experience. This is the reason why Goethe prefers it to refer to his own method: "Every act of seeing leads to consideration, consideration to reflection, reflection to combination, and thus it may be said that in every attentive look on nature we already theorise (« *theoretisieren* ») [12 pxx)]. However, this theory must be built from experience, and we must be aware of this process. Conversely, *die Theorie* has for Goethe a negative connotation when used about Newton, as related to a mere a priori hypothesis; he makes indeed the following analogy: "We compare the Newtonian theory of colours (*die Newtonische Farbentheorie*) to an old castle, which was at first constructed by its architect with youthful precipitation » [12 pxxii]. Coherent with himself, Goethe called the polemic part of his *Farbenlehre: Enthüllung der Theorie Newtons (Unveiling of Newton's Theory)* [13)] and criticises again the fact that Newton would base this theory on an a priori hypothesis [13 §2]. In so far as the opposition Goethe makes between *Farbenlehre* and *Farbentheorie* is systematic, it is a pity to note that this distinction is generally overlooked, when both expressions are translated as colour theory[1]. The reason is probably that *die Theorie* usually does not have in German the negative connotation Goethe gives it when he refers to Newton. And beyond Goethe, the translation of *Lehre* by theory is still frequent[2].

It is worth noting that different French colourists, unaware of Goethe's distinction, stated that they distrusted theories: Monet, Bonnard, Vuillard, Matisse, among others. Their statements are generally interpreted in the sense that they didn't need colour theories because they worked intuitively. I have tried to show that this interpretation is not true (for Monet, see [16 p.293-294]; for Bonnard, see [17 p.130-133), for there is no "innocence of the eye", unlike what Ruskin claimed [18 p.27)]; on the contrary, as Goethe rightly noted in a sentence already quoted: "in every attentive look on nature we already theorise » [12 pxx)]. See also Hanson's well-known statement: "seeing is a 'theory-laden' undertaking" [19 p.19]. Reading more carefully the writings of these artists, it turns out that what they hated was theory as dogma, while they praised the general ideas emerging from discussions within the studio. According to them, there are therefore two kinds of theories: the good ones, because they spring from practice, and the bad ones, which are authoritative and become dogmas that desiccate practice. Such a distinction seems to me to be very similar to that made by Goethe between *Lehre* and *Theorie*. In their heart comes the relationship between theory and practice.

[1] Besides Eastlake, it is also the case of Elie, the French translator of the polemic and of the historical parts of Goethe's treatise [14 p.7].

[2] For instance, Harald Küppers's book *Das Grundgesetz der Farbenlehre* has been translated as *The Basic Law of Color Theory* [15].

What, then, is a theory? It is well-known that the word "theory" derives from the Greek verb *theorein*, to look at, to contemplate. Plato, for instance, uses it in his *Phaedo* [20 65e]. Even though in this dialogue sight depends on the body, while "pure" thought must go beyond the body, it belongs to the general opposition between soul and body: "the soul of the philosopher greatly despises the body" [20 65c). Hence the general opposition between theory and praxis for which Plato is considered responsible, as philosophy is the contemplation of action, at a distance. So, generally speaking, theory means a speculative activity sometimes aiming at reaching the "essence" of things. From this point of view, a theory proposes general or abstract principles ruling a body of fact, a science, or an art, as does "music theory".

Can we content ourselves with such a wide definition? The idea of theory, as a distancing and "objective" thinking completely separated from practice, has been widely criticised in the twentieth century, in particular by the Frankfurt School [21]. Unlike "traditional theory," "critical theory" stresses the necessity of being aware of the fact that the so-called "autonomy" of theory is an illusion and insists therefore on its social determinations [21]. Similarly, the relationship between theory and practice is central in the work of Pierre Bourdieu. From his first anthropological studies in Algeria, he felt it necessary to "sketch a theory of practice" [22], and later to elaborate a "critique of theoretical reason" [first part of 23 p.43-244]. In different other books, he insists on many occasions on the fact that a "theory of theory" is necessary [24 p.220-225), which implies reflexivity. For him a social science requires a reflexive attitude on its practice in so far as there is no "pure" theory; such a pure theory is an illusion supposedly granted by its "objectivity". Now a "theory of theory" must be a reflexive thinking on objectivity itself [25 p.173*ff*].

Keeping in mind the importance of the relationship between theory and practice, we can now try to propose a definition of colour theories. First of all, such a definition is important, as the expression, as we have seen in the previous section, is often considered as equivalent to "text on colour". Now a single statement on colour is not necessarily a theory: a theory requires a conceptual construction and development of ideas about colour. This said, we cannot ignore that the expression "colour theory" is widely spread and used in a huge number of popular textbooks, either in their title, or at least in one or various chapters. Its general (implicit) meaning is what an artist must know in order to use colours. This is explicit in the subtitle of Patti Mollica's textbook: *Color Theory: An Essential Guide to Color – From Basic Principles to Practical Applications* [26]. The key term here is: « guide ». We can find confirmation of it in the entry "Color theory" in Wikipedia: "In the visual arts, colour theory is a body of practical guidance to colour mixing and the visual effects of a specific colour combination » [27]. This is coherent with what has been stressed above: if colour theory is a theory, it is precisely because colour practice requires a "guide," i.e. basic theoretical principles. These principles may vary from one textbook to another, but they generally are more or less the same: colour wheels and diagrams; colour mixtures; pigments and paints; hue, lightness and saturation; colour harmony, and so on. It is striking to observe that most of the time these basic principles are really… basic, repetitive and often based on second-hand sources.

A first definition of colour theory as used in popular textbooks is therefore: *basic principles guiding colour practice*. I propose to call it a weak notion. It should be clear, indeed, that this idea of colour theory is exactly what many colourists dislike, as it suggests/imposes principles and rules. It is particularly obvious when colour harmony is at stake: there are several systems of colour harmony available, but textbooks usually favour one of them because their authors consider it to be the best one, and therefore strongly recommend it.

Besides this weak notion, I propose to formulate a strong definition of colour theory which is more demanding: a set of concepts, general ideas and principles related to colour which in principle (but not

always) should be derived or deduced from practice, experiments, or facts. This definition may – and often will – be argued in philosophical, scientific and artistic theories. We shall not discuss in detail the fields of social sciences like anthropology and psychology because it would be out of the scope of this paper. However, to state it quickly, most anthropological studies of colour are mere descriptions or accounts of the way a given tribe or culture uses colour. Thinking of the different modes of theoretical knowledge in anthropology, Bourdieu distinguishes an objectivist knowledge from what he calls a praxeological knowledge, which means a rupture with the objectivist one, insofar as it requires a reflexivity on its own conditions of possibility [22 p.234-235]. Similarly, most psychological colour studies are accounts of the results of surveys or opinion polls with fixed ideas about colour symbols and their supposed universality (For a critique, see [28]).

However, there are exceptions. In the field of anthropology, and more specifically of ethnoscience, Berlin and Kay's seminal book *Basic Color Terms* contains a colour theory, as it relates the "evolution" of cultures to the number of colours they use in a scale of eleven degrees [29]. One may disagree with it (and there are excellent reasons to do so, see [30, 31 p.322*ff*]), but beyond any doubt it contains a colour theory. One of Berlin and Kay's main statements reads: "there appears to be a positive correlation between general cultural complexity (and/or level of technological development) and complexity of colour vocabulary" [29 p.16]. Now, in the field of psychological studies on colours, an interesting example is Wright and Rainwater's "Meanings of Colour" [32]. Analysing the connotative meanings of colours, they showed that these meanings are much more related to lightness and saturation than to hue, which they were able to formulate in a general rule: "the lighter or the more saturated is a colour, the more 'happiness' it connotes" [32, p.339].

These two exceptions lead to qualify what has been suggested before: what defines a colour theory is not the field itself but the way the issue is dealt with. In the two abovementioned cases, there is an important benefit for the field, and in both cases colour theory, as defined by the "strong definition", can be understood as a *general correlation*: correlation between complexity of culture/technology and complexity of colour vocabulary; and correlation between lightness and saturation, on the one hand, and connotative meaning of happiness, on the other. To be sure, not all strong colour theories take the form of general correlations based on an analysis of practice. Additionally, it might be interesting to recall the following definition given for theory in physics and epistemology: "Set of propositions and definitions taken as a basis, and mathematical deductions whose consequences represent facts and experimental laws known with a precision considered as satisfactory in relation to the measuring tools used" [33 p.1025]. However, such a definition, proposed for physics, is not valid for other fields, as each one has its own purposes, as we will claim in the next section. In what follows; indeed, we will focus on three fields: philosophy, science and art. Now, if philosophical and scientific theories of colour are generally admitted as theories, what about artistic colour theories? According to the definition given above, we cannot consider any artistic statement on colour as a theory of colour. This position might seem reductive, but we need to be coherent: many artists have wonderful insights on colour and their writings are crucial in order to understand their own practice, but they don't necessarily build a colour theory, so that only some of them will be taken into account.

Fields

Philosophical theories of colour

As philosophers like (and build) theories, it is no surprise that part of colour theories is philosophical. They produce concepts: colours are accidents (Aristotle); colours are secondary qualities (Locke, based

on Galileo). Typical of a (contemporary) philosophical approach to colour are the questions we find in Byrne and Hilbert's anthology: "Are physical objects coloured? And if so, what is the nature of the colour properties? These questions form the problem of colour realism" [34 p.XI]. Hence the division of this volume into several categories is defined by different isms: eliminativists (who consider the fact that physical objects are coloured as a mere illusion); dispositionalists, for whom "the property green (for example) is a disposition to produce certain perceptual states: roughly, the disposition to look green" [34 p.XII, author's emphasis] and physicalists (who consider that colours are physical properties). There are also primitivists, who agree with the physicalists that objects have colour, but deny that colours are identical to physical properties (34 p.XII). Not surprisingly, two of the papers in this volume use the expression "theory of colour" in their title: "On Some Criticism of a Physicalist Theory of Colors", and "Physicalist Theories of Color". Indeed, when philosophers discuss texts on colour written by other philosophers, they usually refer to them as "theories". Categories similar to those described above are dominant in continental philosophy, in particular the distinction between "subjectivity" and "objectivity" of colour [35-36].

Scientific theories of colour

Scientists, like philosophers, are also interested in what colour is, but their research is more focused on understanding specific topics. For instance, a volume on colour science [37] (whose companion volume on philosophy [34] has already been mentioned) is divided into problems on which scientists work, namely colour measurement, physiology and psychophysics, colour constancy, colour defects and genetics, comparative colour vision and evolution, and so on. It is hard to give an overview of scientific colour theories, as there are so many different approaches. Roughly, they are about visual perception, colorimetry, colour mixing and colour systems (basic colour terms; colour representation charts); this list is not limitative. They also propose concepts, explanations, and general principles. Let's note that the distinction between subjectivism and objectivism doesn't correspond at all to that between philosophy and science: some philosophers are objectivists and some scientist subjectivists[3].

Artistic and aesthetic colour theories

This field is arguably the most complex to define. Fortunately, we can lean here on a book devoted to this issue: Pawlik's *Theorie der Farbe* [39]. In this book, the author proposes to gather elements from theory, history, didactic and praxis of art [39 p.9] and more specifically of painting. The different chapters are on theories and colour charts, complementary colours, colour contrasts, emotional effects of colour, totality and harmony, and so on. The author doesn't propose a new theory of colour but one inspired by Goethe. It is also worth noting that his book is mainly directed at painters and provides many insights useful to artists wishing to manage colours in their works. From this point of view, Pawlik is right not to separate theory and practice: an artistic colour theory should provide artists with general principles as well as practical tools.

In sum, Pawlik gives a good sketch of what an artistic theory of colour can be. However, the subtitle indicates that the book is an introduction to the conceptual domains of aesthetic colour learnings (*der ästhetischen Farbenlehre*). Is the difference between artistic and aesthetic relevant here? In my view, Pawlik's book mainly deals with artistic theories of art, not aesthetic, even though some aspects such as the concept of totality also have an aesthetic dimension. Where, then, lies the difference? I don't

[3] According to Maund [38] some scientists, for example, S. E. Palmer, S. Zeki and E. H. Land are subjectivists. I thank the anonymous reviewer of a first version of this paper who drew my attention to the work of Barry Maund.

consider aesthetic here in its general meaning of a sub-field of philosophy dedicated to art (as many do), but of general ideas about colour which are pervasive and depend on what I call the imaginary field of colour [40]. Even though I don't share most of these general ideas (full of prejudice, by the way), they exist, and it is important to take them into account in order to better analyse and criticise them. Many of them appeared during the debate between drawing and colour in the seventeenth and eighteenth centuries, among them: colour is decorative, female [41], superficial, deceiving, rhetorical, bodily [42], and so on. Consequently, I think it is important to leave room for those aesthetic theories of colour, besides the artistic ones.

Relationships between the different colour theories

Up to now, we have roughly described some colour theories written by philosophers, scientists and artists. Yet it is important to raise the issue of the relationship between these fields. Classifying different kinds of colour theory is not enough, indeed, if we don't explore the ways each one is related to the other. The specificity of the three fields has been explored by Deleuze and Guattari: philosophy produces concepts, science prospects and art percepts and affects [43, p.29]. Even if this distinction is important, it doesn't help us a lot, as we are not interested here in what each field produces, but in the relationships between the different ways each one apprehends colour.

Philosophy and science

Let's start with philosophy and science. A first comment is of course that before the seventeenth century, both fields were closely related and presumably inseparable, so that it doesn't make sense to ask whether Aristotle's colour theory is philosophical or scientific. Interestingly, in a recently published encyclopedia philosophy and science are grouped into one single chapter in each of the six volumes [44]. Again, if this is not a problem for the volumes on Antiquity, Middle Ages and Renaissance, it might be problematic for the following ones. However, it isn't. In the case of the nineteenth century, it turns out that philosophical and scientific approaches to colour do share a lot, in particular the importance given to physiology in colour perception and a common emphasis on its subjectivity [45]. In the twentieth century Hardin's *Color for Philosophers* played an important part in making philosophers conscious of the importance of contemporary scientific coloru theories. The first sentence of his introduction reads: "What has science to say to philosophy?" (46 p.xix). The anthology already mentioned, *Readings on Color. Volume 1. The Philosophy of Color* follows the same path, noting that "philosophers have become increasingly aware of the relevance of science to philosophy" [34 p.xi)]. Now, even though philosophical and scientific colour theories have a lot in common, their purposes remain different. Philosophers are more focused on issues like the nature of colour, as well as colour realism, i.e., the debate on whether the objects in the external world are coloured or not. In other words, they are generally more interested in how problems of colour raise philosophical, ontological, and epistemological issues, while scientists are rather worried about more specific issues, as those mentioned above, and try to answer concrete questions about colour perception, measurement, systems, and so on.

Philosophy and art

Philosophers are sometimes interested in colour in art. One of the best examples is the late Jacqueline Lichtenstein. Her innovative book The Eloquence of Color [42] is an excellent philosophical contribution to the aesthetic problems raised by colour in painting. Yet more interesting for our purpose is not how philosophers analyse colours in art, but rather what both fields may have in common. From

this point of view art historian Meyer Schapiro wrote a very stimulating essay, suggesting that paintings may have a philosophical content, and share with philosophers a worldview, understood as "an attitude, unarticulated, unformulated, implicit in values, choices and reactions" [47 p.21]. Such a worldview also applies to colour, as Schapiro emphasises: "To be an artist is not simply to have aesthetic ideas, but to work at the aesthetic ideas, to weigh their consequences for the colours and shapes that one uses and for their effect upon a unity to be attained, a harmony, and a particular expression. It is in this sense that I wrote these comments on the relations of philosophy and painting" [47 p.48]. Berkeley and Monet provide a good example of a worldview on colour shared by a philosopher and an artist. Schapiro is clear about the fact that they didn't know each other, and that Monet would have considered distasteful "Berkeley's spiritualist metaphysics" [47 p.39)]. However, Monet's insistence on the sensations of colour in his paintings echoes Berkeley's statement: "All that is perceived by the visive faculty amounts to no more than colours, with their variations and different proportion of light and shade" [48 p.234]. Such a suggestion seems to me quite useful in exploring further the possible interrelations between philosophical and artistic colour theories.

Science and art

Another aspect of the complex relationships between colour theories is about science and art. Here there are different ways of raising the issue: in my opinion, the question is not to decide whether artists can have scientific practice. In the case of Seurat, one of the painters most interested in physiological optics, some consider that his works are pseudo-science as he didn't understand anything about colour science, while others hold that his works show that he has a good command of the colour science of his time. I've tried to show that this debate has a lot to do with the opinion one has about "science" [49]. Much more important is, again, the issue of what scientists and artists can share. For example, Neo-Impressionist painters have in common with Helmholtz a very similar symbolist worldview [49], and more generally Helmholtz groundbreaking conception of sensation can be paralleled with the way some artists (Cézanne, Matisse, Bonnard amongst others) manage colour sensations in their canvases [50].

Besides these similarities, important differences between scientific and artistic colour theories must also be stressed. In this last section, I will elaborate on them. My own interest for this tension came from my work on the French chemist Chevreul and his influence on artists [16]. His ideas, indeed, have often been misunderstood. But how are we to understand this divergence, if we discard the idea that the painters could not grasp scientific data too complicated for them? It is, indeed, not due to a lack of understanding, as if the artists would miss training in the scientifical field, but rather of *misunderstandings*. A good example is colour enhancing and intensification. A frequent misunderstanding of Chevreul's experiments was the belief that he recommended what he called harmony of contrast, i.e., the juxtaposition of complementary colours instead of harmony of analogous colours. Yet, if we read Chevreul carefully, it turns out that he never recommended to painters such a juxtaposition. But the painters eagerly wanted to intensify their colours and just paid attention to what could help them in doing so. It is the reason why they just retained that the juxtaposition of complementary colours "produce only a *simple augmentation of intensity* in their respective colours" [51 §38; Chevreul's emphasis]. Now, if it is true that Chevreul praised complementary colours, it is not because they mutually enhance each other when close, but because their hues are not tinted by another hue: they remain the same. As he put it: the association of complementary colours "is the only association where the colours mutually improve, strengthen, and purify each other without going out of their respective scales" [51 §845]. Furthermore, Chevreul explicitly advised painters NOT to juxtapose complementary colours in their canvases because the phenomenon of simultaneous contrast produces

itself anyway [51 §330]. Consequently, such a juxtaposition would be an exaggeration and the artist wouldn't be faithful to nature when exaggerating an effect that produces itself at any rate [51 §332].

The reason for this misunderstanding is that Chevreul produced a scientific theory of colour, even if his huge treatise is directed at artists. His concern remains scientific, not artistic. When he sometimes recommended the use of complementary contrast, it was not for aesthetic but rather utilitarian reasons, for instance in the case of army uniforms: if the trousers and the jackets of officers are of complementary colours, they enhance each other so that they can be used more times even when faded. As a scientist, Chevreul wanted to understand several chromatic phenomena from the point of view of their physiological mechanisms. His law of simultaneous colour contrast is an explanation of the reason why two colour samples, when juxtaposed, tend to be perceived more differently than when seen separated. Conversely, artists are guided by an artistic rule: that of colour intensification, which is quite foreign to scientific concerns. For Chevreul, the fact that two complementary colours enhance each other when juxtaposed is a side effect of his law, and never an aim. And even if vision science deals with colour intensification (colour opponency mechanisms, see [52]), this research has not been conceived of as a guide for aesthetic harmony.

The second and last example is taken from Ogden N. Rood, physicist at Columbia and author of a book directed at artists [53] in which he proposes an interesting and clever experiment based on a Maxwell disk, composed of two circles (Figure 1). The small central disk is painted with vermilion and ultramarine blue, previously mixed on a palette, while the outer disk is painted with vermilion and ultramarine blue covering each one half of the outer circle. When the disks were in movement, the result was the following: "the larger disk became tinted red-purple, alongside to which the smaller disk seemed grey, so dull and inferior was its colour. The real colour of the smaller disk was a dull violet-purple" [53 p.147].

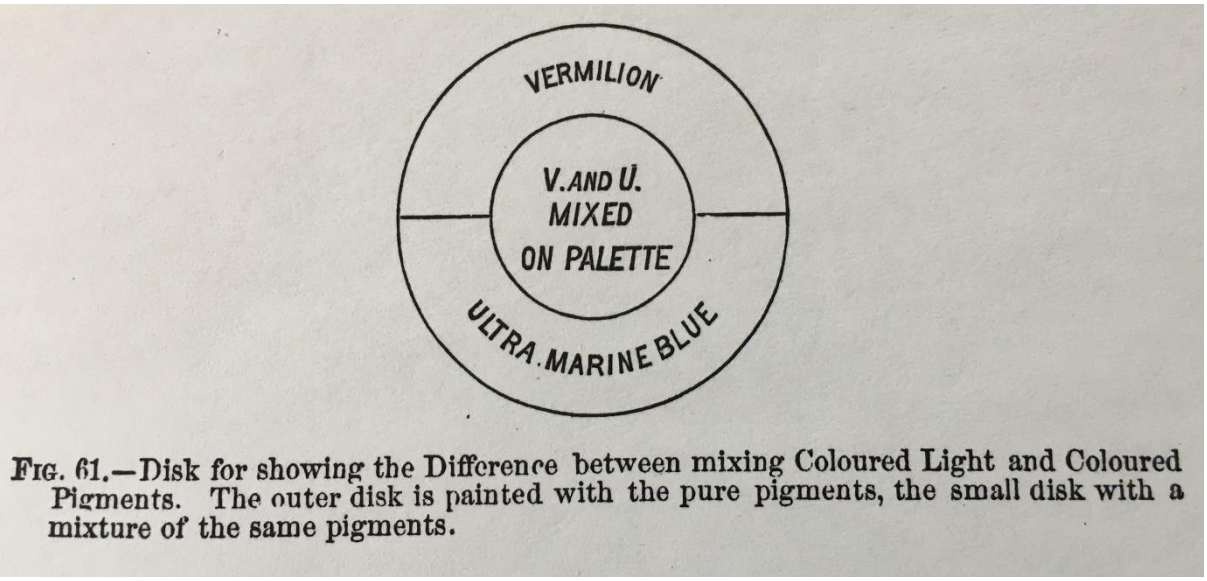

FIG. 61.—Disk for showing the Difference between mixing Coloured Light and Coloured Pigments. The outer disk is painted with the pure pigments, the small disk with a mixture of the same pigments.

Figure 1: Illustration from O.N. Rood, Students Textbook of Color of Modern Chromatics with Applications to Art and Industry*, New York, D. Appleton & Company, 1899.*

Now, in order to match the two disks in rotation, Rood had to add a lot of black to the outer disk. From this experiment, he concluded that "The large amount of black which it was necessary to add strikingly illustrates the general proposition that every mixture of pigments on the painter's palette is a stride towards blackness" [53 p.147]. This conclusion struck the Neo-impressionist painters, and one of their main critics, Fénéon, quoted it in one of his papers [54]. Here there is a new misunderstanding.

Rood's starting point is the difference between subtractive and additive colour mixture, and he was led to compare "the results which are obtained by mixing coloured *lights* with those which are given by a mixture of coloured *pigments*" [53 p.141, his emphasis]. He knew indeed that the additive mixture of complementary coloured tends to white, while their subtractive mixture tends to black. What is interesting in his experiment is to match the results in order to give a similar result in both spinning disks. Rood's is clearly a scientific theory of colour, aiming at stressing that an important amount of black must be added to the outer disk in order to get a similar result to that obtained by the same two colours mixed on the palette. But the Neo-impressionist artists understood it in a different way, as they were fascinated by the possibility of reaching in their works a luminosity similar to that of colour-lights. In other words, Rood makes an experiment and observes that the temporal mixture of two separate complementary hues is more luminous than their mixture on a palette. His is a scientific theory of colour. The artist, however, wants, as noted Signac "to make colour as brilliant as possible by creating coloured lights, thanks to the optical mixture of juxtaposed pigments" [55 p104]. Signac reacts as an artist interested in building an artistic colour theory partly drawn from scientific data, and whose aim is to provide him with a set of rules, principles, ideas or "laws", in order to guide his practice or to legitimate it a posteriori. In this case (for the other elements of his colour theory, see [56]), he stresses the luminosity of colours.

This difference of aims between scientific and artistic colour theories is also patent in the vocabulary and concepts they use. Signac indeed uses the concept of *optical mixture*. This was already the case in Fénéon's manifest:

"Need one be reminded that for the same colours, the mixture of pigments and the mixture of lights do not necessarily produce the same results. One knows as well that the luminosity of an optical mixture is always much greater than that of a pigmentary mixture, as shown by the numerous equations for luminosity established by Rood" [54 p481].

Now, Rood never uses the expression of "optical mixture" which belongs to the artistic colour theories. It has been coined by an art historian, Charles Blanc, who defines it so: "Two colours in juxtaposition or superposed in such or such proportions, that is to say according to the extent each shall occupy, will form a third colour that our eye will perceive at a distance, without having been written by weaver or painter. This third colour is a resultant that the artist foresaw and which is born of optical mixture" [57 p.475]. Why did Blanc find it necessary to coin this new concept? In order to explain "the marvellously rich effect produced by Delacroix" who "had slashed the naked back of his figure with a decided green, which partly neutralised by its complementary rose, forms with the rose in which it is absorbed a mixed and fresh tone apparent only at a distance, in a word a *resultant* colour which is what is called the optical mixture" [57 p.475]. In other words, Blanc tries to explain why Delacroix was "one of the greatest colourists of modern times, one might even say the greatest" [57 p.472] and found a reason in his use of optical mixture, which Blanc therefore recommend to painters in order to strengthen their colours. Hence, the great interest Fénéon and Signac had for optical mixture.

Rood doesn't need to use the concept of "optical mixture" as for him a spinning disk is part of an additive mixture (which should be slightly nuanced [58]), as distinct from a subtractive mixture. Conversely, for painters, the distinction between additive and subtractive mixture is not relevant, as they work with pigments only (however, it is important for them not to confuse the results of mixing pigments and lights). Now, it seems to me that unintentionally, Rood favoured the misunderstanding when he wrote in the caption of his illustration that it deals with a "Disk for showing the Difference between mixing Colored Lights and Colored pigments" [53 p.146). This sentence is a possible source of confusion: in fact, strictly speaking, Rood worked with vermilion and ultramarine blue *pigments*, not with coloured lights, even though when in movement, the outer circle produces a mixture similar to that

obtained by coloured lights. This confusion helped the critic Fénéon and then the Neo-Impressionist painters to believe that they could get in their paintings a luminosity similar to that of coloured lights. Fénéon wrote indeed about the optical mixture: “these colours, in isolation from each other on the canvas, recombine on the retina. One has, therefore, not a mixture of coloured matter (pigments) but a mixture of coloured lights” [54 p.481].

I hope that these two examples clearly show that scientific and artistic colour theories can be close to each other and interact, but that their aims remain different. Hence the necessity of keeping a distinction between them. More generally, the same can be said about philosophical colour theories. In this last section, I have insisted on the way these different theories can in some cases overlap, taking as examples certain cases, particularly scientifically enhanced artistic colour theories, as well as scientifically enhanced philosophical colour theories. However, besides them there are also mere artistic and philosophical colour theories. They obviously all belong to colour theories, an important sub-field within the huge domain of colour studies that deserves further research in order to better understand their similarities but also their specificity.

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