CHEVREUL'S COLOUR THEORY AND ITS CONSEQUENCES FOR ARTISTS

BY

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- the national features of colour practice (see "Colour in French Painting", postface to *Colour since Matisse*, New York, Taplinger, 1986; *L'expérience de la couleur en France après 1945* (ed.), Marseille, Galerie de l'Ecole d'art, 1990; *El color en el arte mexicano* (ed.), Mexico, UNAM, 2003).
- Case studies of chromatic systems (see his book *La Stratégie de Bonnard. Couleur, lumière, regard*, Paris, Gallimard, 2006, as well as articles on Ayme, Delaunay, Rothko, Seurat, Vantongerloo, etc.)
- Aesthetics issues (several papers on colour and harmony, gender, ethics, drawing, etc.)

The Colour Group (GB) has established a series of
Occasional Publications of which this is the second.
The first was *Emulous of Light: Turner's Colour Revisited*
by Dr John Gage (2010) which is available from
http://www.colour.org.uk/archive.html

I WOULD LIKE to thank the Colour Group (Great Britain) for inviting me to deliver this paper at the meeting *Colour and Textiles: From Past to Future* in June 2010 in Paris, and for publishing it. I feel very honoured and grateful for this opportunity I am given to introduce to the British public a summary of my work on Chevreul, which, unfortunately, has not previously been available in English.

In the first part of this paper, I would like to outline Chevreul's famous law of simultaneous contrast of colours. In the second part, I will try to explain why this law has been so important for artists, and give some examples.

1. The law of simultaneous contrast of colours

a) Chevreul's life and work

Michel-Eugène Chevreul was born in Angers, in 1786. Aged seventeen, he came to Paris, with a letter of recommendation for Vauquelin, an important chemist of the time. He was appointed at the National Museum of Natural History as an assistant in charge of the chemical analysis of samples. His whole career as a chemist was determined by one sample of soap that Vauquelin asked him to analyse. At this date the very nature of animal fats was still unknown and, after around ten years of research, Chevreul published the book that gave him his fame as a chemist: *Chemical Researches on Animal Fat* (1823). In this he was able to show that animal fats contain the different acids he isolated and to which he gave names (margaric, stearic, oleic, etc.). His discoveries led to important industrial improvements, for example in the field of candles. As he was also very interested in issues of epistemology, he wrote another book on matters of method, to explain how he had been led to such important discoveries.

The same year when his second book, *General Considerations on Organic Analysis*, was published, i.e. in 1824, an important event occurred that changed forever the course of his career: he was appointed Director of the dyeing department at the Gobelins Manufacture. After four years of research in the field of colour he wrote a Memoir that was read at the Academy of Sciences in April 1828: *Memoir on the influence that two colours can have on each other when seen simultaneously*. However, the preparation of his main book on the topic took eleven years more, in particular due to the problems of finding reliable colour plates in order to illustrate it. The volume was eventually published in 1839. Literally its title is "*On the law of simultaneous contrast of colours and on its applications to…*", followed by an impressive list of all the fields to which this law can be applied, including tapestry, of course, but also painting, carpets, clothing, horticulture, stained glass windows, and so on. The book was immediately translated into German (1840). Then a translation by Thomas Delf (under the pseudonym of Charles Martel) was published in England in 1854, followed by another translation due to John Spanton, published in United States in 1857. This book was the first of a series of important publications by Chevreul in the field of colour, amongst which are his *Chromatic Circles* (1855), *Outline of a Way to Define and Name Colours* (1861), and *On Colours and on their Applications to Industrial Arts* (1864) (Plates 1 and 2).

Plate 1: First chromatic circle containing pure hues, from *Cercles Chromatiques de M. E. Chevreul* (Paris: Didot, 1861)

b) The law of simultaneous contrast

Chevreul worked at the Gobelins for almost sixty years and finally retired in 1883 at the age of 97. Three years later, his one hundredth birthday was celebrated as a national event. On this occasion, the famous photographer Nadar and his son made a series of portraits (Plate 3). Chevreul finally died at 103.

From the beginning of the Nineteenth Century, the Gobelins Department of Dyes had been directed by a chemist, and this is why they appointed Chevreul, one of the most famous chemists of the time. Why a chemist? The reason was that the task of this Department was to take care of the dyes of wools and silks to be used by the three manufactures (Gobelins, of course, for tapestries, but also La Savonnerie for carpets and Beauvais in the case of tapestries for furniture). This complex task implied consideration of several issues:

- the quality of the wool, and in particular cleaning it from its grease, and bleaching it;
- the dye stuff: determining the qualities of the dyes according to their stability, their brilliance and to which kind of cloth they were to be applied: wool, cotton or silk;

- the complex issue of colour classification, which remained at the time rather empirical: when the weaving department needed a nuance of say, a blue, they used to present a thread of that blue for matching. As Chevreul rightly noted, that method was not very practical, for they had to grope in order to find a dye that could match the sample. It was therefore necessary to create a chromatic circle proposing a general classification of colours to which both weavers and dyers could refer with a shared frame of reference.

Plate 2: Circular zones of continuous colours, from *Cercles Chromatiques de M. E. Chevreul* (Paris: Didot, 1861).

b) The law of simultaneous contrast

Although Chevreul's work on colour covers many aspects, I will focus on the law of simultaneous contrast of colours, as expounded in his book translated into English under the title *The Principles of Harmony and Contrast of Colours and their Application to the Arts* (1st ed. in French, 1839). Its starting point was a complaint from the weavers of the Gobelins against the dyers of the Department of dyeing that he directed. The complaint was in particular about the black samples of wool used for the shades of blue and violet draperies. As a chemist, Chevreul first tested the wools dyed in black in his workshop and compared them with those dyed in the best places from London and Vienna.

After a careful comparison, he realized that the quality of the dyed material was not in question. This led him to raise a brilliant hypothesis: the lack of strength of the blacks was not due to the dyes or their uptake but was a visual phenomenon related to the colours juxtaposed to the blacks.

This hypothesis in turn had important consequences for his work. Indeed, he came to the Gobelins as a chemist in order to solve problems of dyeing, but he quickly found out, thanks to his *a posteriori* experimental method, as he called it, that the problem was not a problem of chemistry, but one of psychophysiology. Hence his researches on the interactions between contiguous colours that led to his famous law of simultaneous contrasts of colours:

> In the case where the eye sees at the same time two contiguous colours, they will appear as dissimilar as possible, both in their optical composition and in the strength of their colour.[1]

Plate 3: Paul Nadar, photographic portrait of Cheveul at the age of one hundred years, 1886.

What does this mean? Roughly speaking, according to Chevreul, the brain has a tendency to exaggerate differences in order to perceive them better, above

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[1] M.-E. Chevreul, *The Principles of Harmony and Contrast of Colours and their Application to the Arts,* a newly revised edition by Faber Birren, based on the first English edition of 1854, West Chester, Penn., Schiffer Publishing Ltd., 1987, § 16.

all along the borders where two different hues are juxtaposed. This law works, as Chevreul rightly claimed, for lightness, as well as for hues, as illustrated by Chevreul in Plate 4: if we juxtapose two samples of grey, one lighter and the other darker, the lighter is perceived even lighter, and the darker even darker, especially around the border line. This contrast is cleverly made more obvious when we compare the two samples: O and O', as well as P and P', which have exactly the same degree of lightness; however, our perception of the samples differs when we see them in isolation and juxtaposed to another sample of a different degree of lightness. The bottom of the same plate shows an effect known as "Chevreul's illusion": "the stripes, seen from a suitable distance, resemble channelled grooves (*glyphs*) more than plane surfaces"[2]. This is due, as Chevreul explains, to a double contrast: each stripe (except the two extremes) being lighter than the following (when seen from left to right), a double effect is produced, because the left half of each stripe will appear darker and the right half lighter, due to the influence at the edges of the preceding and following stripes.

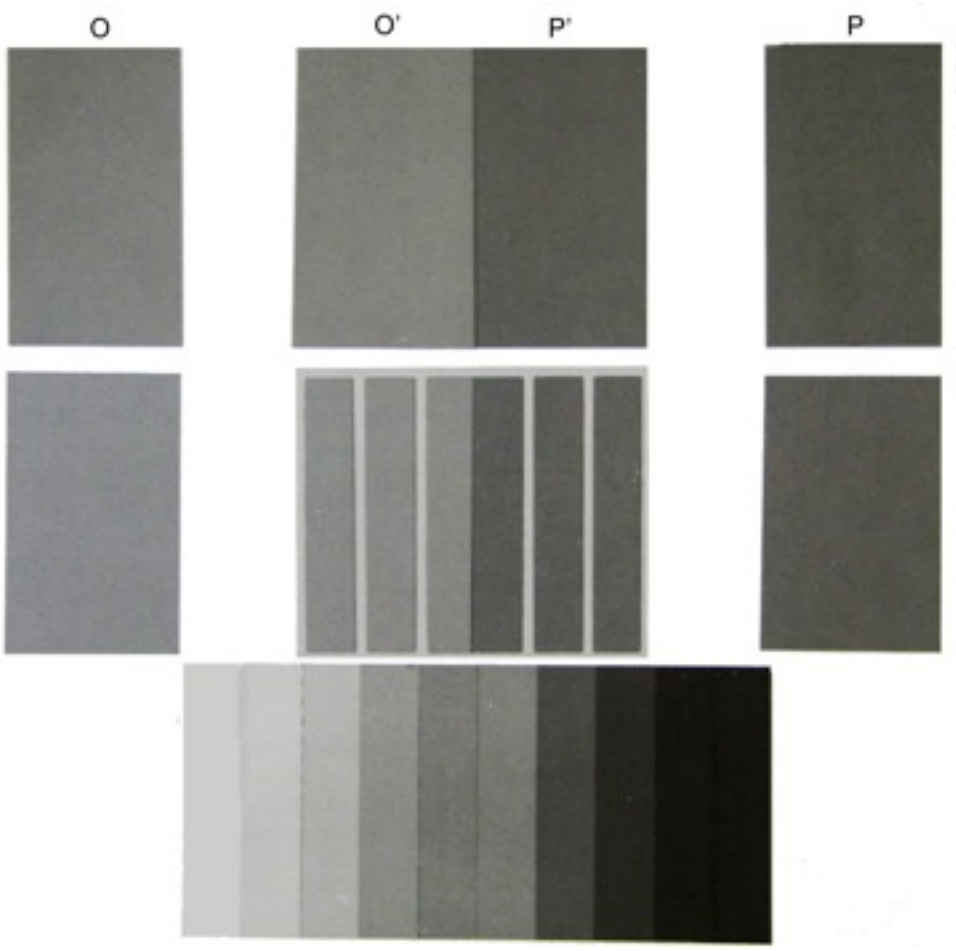

Plate 4: Illustration of the contrast of lightness; redrawn detail from original figure by M.-E. Chevreul, *De la loi du contraste simultané des couleurs & etc.*, 1839.

[2] M.-E. Chevreul, *The Principles of Harmony and Contrast of Colours, op. cit.*, § 11.

Now, what happens when we perceive two juxtaposed hues? Here it is worth quoting the main definition of simultaneous contrast:

> If we look simultaneously upon two stripes of different tones of the same colour, or upon two stripes of the same tone of different colours placed side by side, if the stripes are not too wide, the eye perceives certain modifications which in the first place influence the intensity of colour, and in second, the optical composition of the two juxtaposed colours respectively. Now as these modifications make the stripes appear different from what they really are, I give to them the name of *simultaneous contrast of colours*; and I call *contrast of tone* the modification in intensity of colour, and *contrast of colour* that which affects the optical composition of each juxtaposed colour".[3]

Now what kind of modifications do we perceive? In the case of contrast of lightness, as already said, the modification consists in an exaggeration of difference, as the lighter stripe will appear lighter and the darker even darker. But when two hues are juxtaposed, what could exaggeration of difference mean?

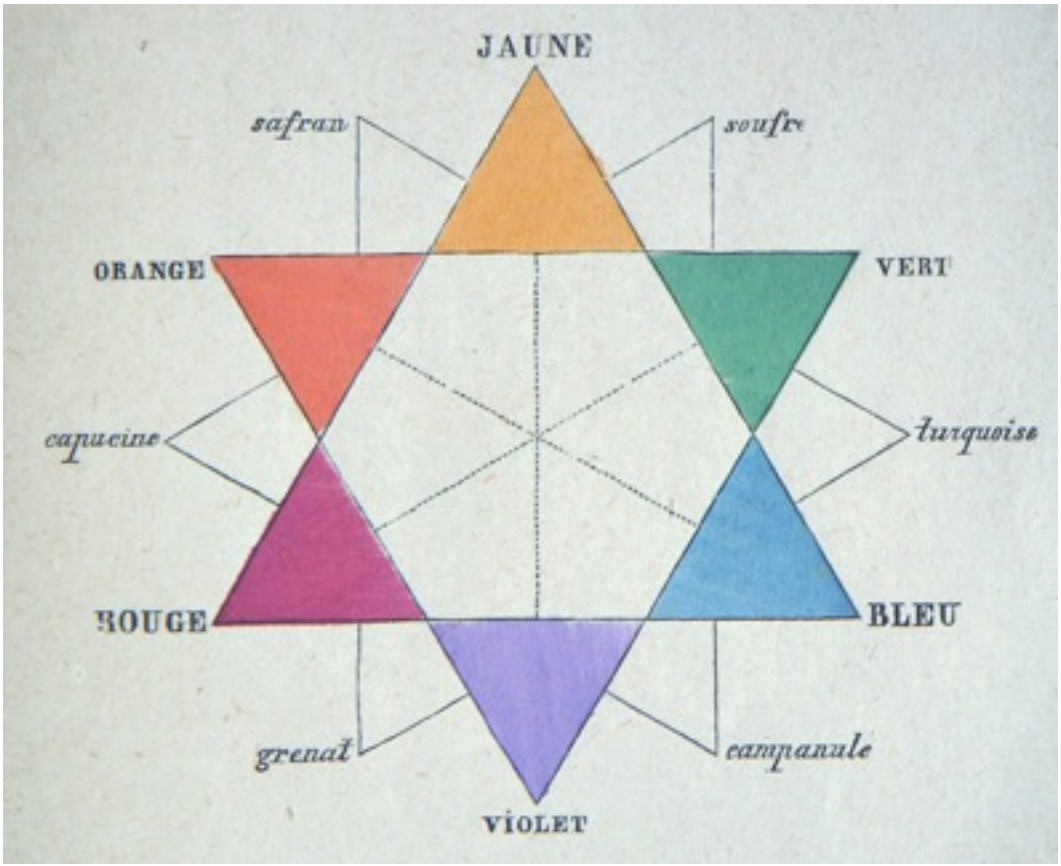

Plate 5: *Chromatic rose*, from Charles Blanc's *Grammaire des arts du dessin,* 1867. The colours in the original figure are faded and the saturation has been increased in this reproduction.

[3] *Ibid*, § 8, Chevreul's emphasis.

To understand, it is necessary to say a few words about the concept of complementary colours. First, it was known from Buffon's observations, published in 1743, that if we look for a long time at a red spot on a white sheet of paper, after a while we will see a pale green area all around the red spot.[4] And if we stop looking at the red spot, and look instead at the white sheet, we will see a green spot of the same shape as the spot. Buffon called these observations "accidental colours" because they depend on the eye. Yet Buffon is one of Chevreul's sources when the latter tried to understand the reason for colour interactions when they are seen in juxtaposition. Another of his sources is a Memoir by Hassenfratz about coloured shadows,[5] a study of the shadows produced when an object is lit by two differently coloured light sources. He noted that when there are two shadows their colours are what he proposed to call complementary to each other. So, if the first is red, the second will be green, and so on for the other pairs of complementary colours: orange and blue, yellow and violet. A popular scheme for memorising complementary colours was given by Charles Blanc (1867) (Plate 5), a source avidly read by Neo-Impressionists and Post-Impressionists painters.

Chevreul was aware of the existence of complementary colours, which helped him to formulate his law of contrast. Indeed, they were considered as the most opposed colours hence Chevreul's hypothesis, that if the brain tends to exaggerate the difference between juxtaposed colours, it means that the colours will be perceived as more different than they really are. This is easy to understand for lightness, but what's happening in case of juxtaposed hues? Or in other words, what does it mean for hues to be perceived as more different than they actually are? The answer has to do with the complementary colours as these are considered the most opposed. Therefore Chevreul thought – and this idea is at the heart of his law of simultaneous colours – that two juxtaposed hues will be perceived as the most different possible when the brain adds to a perceived hue a little of the complementary of the juxtaposed hue, and vice versa.

Concretely, explains Chevreul, if we look at a white pattern on a coloured ground (Plate 6), we will perceive this white pattern - here the vertical motif - slightly tinted by the hue complementary to that of the ground. So, from top to bottom, on a red ground they will appear greenish, on an orange, bluish; on a yellow one, they will appear slightly violet; on a green one reddish; on a blue ground, the white looks slightly orange. And finally, and on a violet ground, they look yellowish.

From a practical point of view, Chevreul's law works well and is quite useful. To give an example, Chevreul was once asked to testify as an expert on colours in a trial between a wallpaper manufacturer and the industrialist for whom the wallpaper had been made. The problem was exactly the same as the one we

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[4] Buffon, « Sur les couleurs accidentelles », *Mémoires de l'Académie des Sciences,* 1743, reprinted in J.-L. Binet and J. Roger (eds.), *Un autre Buffon,* Paris, Hermann, 1977, pp.138-149.

[5] J.H. Hassenfratz, « Premier mémoire sur les ombres colorées », *Journal de l'École Polytechnique*, t. IV., 1802, pp.272-283.

just examined. The industrialist had ordered wallpapers with a grey pattern on a green background but when he received them, he refused to pay, arguing that the grey pattern looked reddish. Hence the trial. With a great sense of humour, Chevreul explained that both the manufacturer and the client were right: the former who claimed that the grey pattern was perfectly grey and the latter who claimed that the grey was reddish. To show it, he cut out in a white sheet the exact contour of the grey pattern and placed it over the wallpaper in order to hide the green background and replace it by the white of the sheet. Seen this way, the grey pattern looked quite grey. Then Chevreul suggested a solution to the problem: adding to the grey a small part of the colour of the background, in this case green, in order to neutralise the complementary effect.

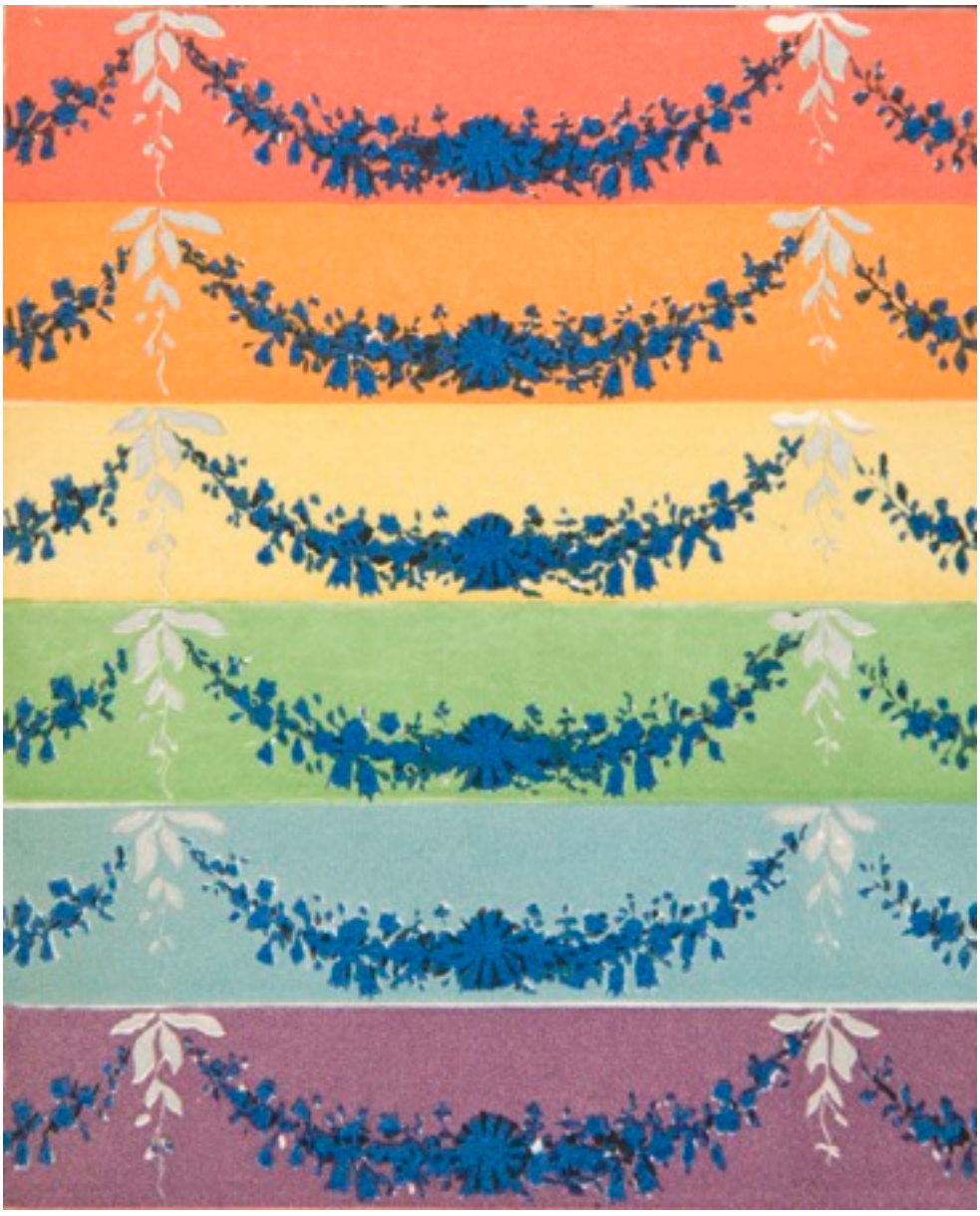

Plate 6: One of the plates illustrating M. E. Chevreul's *The Laws of Contrast and Colour & etc.*., Routledge, Warnes, and Routledge, 1859.

We can now understand the explanation of the problem Chevreul had with the blacks dyed in his workshop, which was the starting point of his discovery. The complaint of the weavers, if you remember, was about the blacks used for the shades of blue or violet draperies. Yet, when blacks were juxtaposed to blue, they appeared slightly tinted with the complementary colour of blue, which is orange. And when blacks were juxtaposed to violet, they looked yellowish.

Another important point must be mentioned: what happens when the two hues are complementary, for example, when we look at two contiguous colour samples, a green and a red? According to the law of simultaneous colours, the green will be tinted by the complementary hue of the contiguous colour and vice versa. Now the complementary colour of red is green, and of green is red. As a consequence, the green will be perceived as greener and conversely the red will be perceived as redder. Hence Chevreul's conclusion that when two complementary colours are juxtaposed they enhance each other, was crucial for painters who wished to predict colour harmony and colour intensity when they juxtaposed colours.

In the last part of his book, Chevreul extended his hypothesis to state that the brain has a tendency to exaggerate differences. Even though Chevreul's hypothesis has been confirmed by progress in visual neuroscience, the demonstration of his law is not very satisfying from a theoretical standpoint, which he himself later admitted. Furthermore, Chevreul's is not the only explanation possible for the phenomenon of colour contrast: another Frenchman, the mathematician Gaspard Monge, had published in 1789 a stimulating paper in which he explained colour contrast as a consequence of colour constancy. Colour perception, according to Monge, is relative to our estimate of the illuminant.[6] The reason why Chevreul never took into account Monge's paper, although it had been published in a prominent journal, is probably political, and not scientific, as John Mollon suggests.[7] Whereas Chevreul was rather conservative in politics, Monge embraced the Revolution, became a member of the Jacobin Club and was a friend of Napoléon.

c) The law of simultaneous contrast qualified

Even though Chevreul's law is still valid and if his distinction between simultaneous and successive contrast is still in use nowadays, it has often been criticized both at the end of the nineteenth century as well as by various modern scholars. Some critiques concern his definition of complementary colours. Here is the controversial paragraph where he gave his definition:

> Let us now return to the relation which exists between the coloured light *absorbed*, and the coloured light *reflected*, by an opaque body, which makes it appear to us of the colour peculiar to this light. It is evident, from the manner in which we have considered the physical composition of solar light, that if we

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[6] G. Monge, « Mémoire sur quelques phénomènes de la vision », *Annales de chimie,* 3, 1789, pp.131-147.

[7] J. Mollon, « Monge. The Verriest Lecture, Lyon, July 2005 », *Visual Neurosciences,* 23, 2006, pp.297-309.

> reunited the total quantity of the coloured light *absorbed* by a coloured body, to the total quantity of coloured light *reflected* by it, we should reproduce white light: for it is this relation that two differently coloured lights, taken in given proportions, have of reproducing white light, that we express by the terms *Coloured lights complementary to each other*, or *Complementary colours*. It is in this sense we say:
>
> That Red is complementary to Green, and *vice versa;*
> That Orange is complementary to Blue, and *vice versa,*
> That Greenish-Yellow is complementary to Violet, and *vice versa*
> That Indigo is complementary to Orange-Yellow, and *vice versa.*[8]

One of the main critiques is that Chevreul has confused mixture of lights and mixture of pigments, i.e., additive and subtractive mixtures respectively. Indeed we know that the rules of mixture are different for lights and pigments and that the results of the mixture are also different: it produces white in the first case, and black, or dark grey, in the second. So the critique is that Chevreul confounded two different conceptions of complementary colours that are incompatible. When he writes about "this relation that two differently coloured lights, taken in given proportions, have of reproducing white light", he refers to the additive mixture of lights, but when he writes that "if we reunited the total quantity of the coloured light *absorbed* by a coloured body, to the total quantity of coloured light *reflected* by it, we should reproduce white light", he refers to the subtractive mixture. It is true that the concept of complementary colours had been proposed before Helmholtz made explicit the distinction between additive and subtractive mixture, but this confusion was pervasive at the time.

Another, additional, critique is that the first part of the definition, that which concerns additive mixture, would be incompatible with the examples of complementary colours he gives, which seem to concern subtractive mixture (red/green, orange/blue, etc.). Does this mean that Chevreul confused mixture of lights and mixture of pigments? I don't think so, for he later explained that in order to determine the complementary colours, he used Arago's polariscope, as did Brücke twenty years later when he built another polariscope he called the "schitiscope" in order to determine the complementary colour of a given hue.

However, one might argue that green and red are subtractive and not additive complementary colours. That's true. But if we read the literature of the time on additive complementary colours, we quickly find out that green and red were considered to be *additive* complementary colours, that is, that when mixing additively, we get white. It is, in particular, the view of Hassenfratz and of many other physicists of the time as well. The reason is that the colours used (as well as those determined with the help of a polariscope) were not monochromatic. Indeed if we were to mix additively green and red, we might get white, instead of yellow, if the green were a blue green (cyan); alternatively, we could also obtain white with a pure green mixed with a red that tends to magenta.

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[8] M.-E. Chevreul, *The Principles of Harmony and Contrast of Colours, op. cit.*, § 6, Chevreul's emphasis.

Another critique is that Chevreul confused the principle of contrast with what is called assimilation. Indeed, the validity of Chevreul's law depends on the size of the juxtaposed colour samples. If the visual angle subtended is not large enough, there is no contrast, but, on the contrary, the two juxtaposed colours tend to fuse, so that the resulting colour is an average between the two juxtaposed samples. Yet in his work with tapestry, Chevreul had to deal with thin threads of wool. Hence the idea that he didn't grasp the importance of the size of the colour samples and confused accordingly contrast and assimilation. However, if we read Chevreul's book carefully, we realise that he scaled the difference between the two phenomena according to the size of the samples:

> There is a *contrast of colours* whenever differently coloured surfaces are properly arranged and susceptible of being seen simultaneously and perfectly distinct from each other; and we must remember that, if a blue surface be placed beside a yellow surface, instead of inclining to green, they, on the contrary, differ from each other, and acquire red.[9]

Unlike the contrast of colours, Chevreul distinguished what he called mixture of colours:

> There is a *mixture of colours* whenever materials of various colours are so divided and then combined that the eye cannot distinguish these materials from each other: in which case the eye receives a single impression; for example, if the materials are a blue and a yellow of the same strength, and in proper proportions, the eye receives an impression of green.[10]

Yet Chevreul introduced this distinction precisely when he was writing about the specificity of tapestry and about the mixtures of threads. This shows that he was quite aware of the difference between the two principles, even if he considered that the colour induced in case of assimilation was not an optical average, but a subtractive mixture.[11]

2. Chevreul's influence on artists

In the second part of this paper I would like to give a quick overview of the influence of Chevreul on some painters. Before starting, it might be useful to sketch the frame in which the relationship between his theory and artists' practice has taken place. Indeed, it seems to me that this relationship has suffered from many misunderstandings, one of which concerns colour harmony. Even if Chevreul is still considered as having favoured the harmony of complementary colours, he was more a partisan of what he called "contrasts of analogous colours", that is colours that have a similar lightness. However, in so far as the new dominant paradigm of colour harmony was that of

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[9] M.-E. Chevreul, *The Principles of Harmony and Contrast of Colours, op. cit.,* § 375, Chevreul's emphasis.

[10] *Ibid.,* § 374, Chevreul's emphasis.

[11] For a comparison between optical and subtractive mixture of the three primary colours of the painter, see J. Filacier, *La pratique de la couleur*, Paris, Dunod, 1986, p.51.

complementary colours, artists took Chevreul – as popular accounts of his law also did – as advocating the harmonic use of complementary colours, as if he, too, belonged to the mainstream. This is due to the fact that in most cases painters only had a second-hand command of the chemist's theories. Seurat, for instance, once explained that he got acquainted with Chevreul's ideas through Charles Blanc. And indeed, Blanc wrote that "it is the reciprocal heightening of complementary colours in juxtaposition that M. Chevreul called 'The law of simultaneous contrast of colours' ".[12] Note that Seurat was not an isolated case. Blanc's theories also had a great impact on many other artists, including Signac, Gauguin and van Gogh.

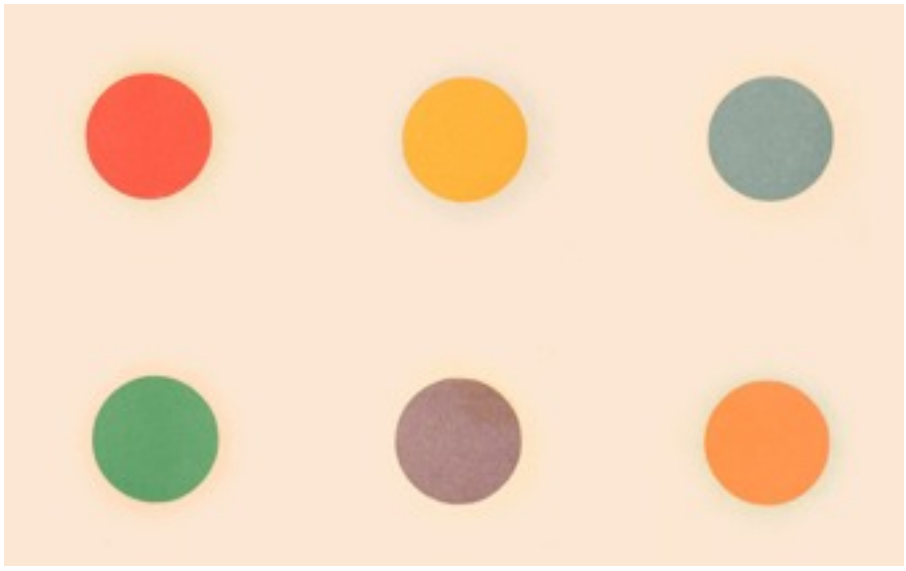

Plate 7: Illustration of the law of simultaneous contrast; originally published in *De la loi du contraste simultané des couleurs & etc.*, M. E. Chevreul, 1889. The effect is exaggerated in the original plate but the colours have faded so that the effect is no longer so obvious.

Another source of misunderstanding has been the belief that Chevreul would have recommended painting simultaneous contrasts of colours. In this case, he may have unintentionally contributed to the misunderstanding. In order to make his law visually more effective, Chevreul published a plate that made a deep impression on painters (Plate 7), showing how on a white ground, when we stare at small disks of pure colours, we perceive a fringe effect as a halo of the complementary colour all around the disk. These disks, in which Chevreul consciously exaggerated the effect since the ground around the disk was tinted, had an unexpected consequence in so far as they gave artists the impression that they had to do the same, i.e. tint the background around a colour with its complementary colour, even though Chevreul explained that he was exaggerating the effect only to make it more visible. According to the

[12] Ch. Blanc, *Grammaire des arts du dessin,* 1867 ; I am quoting here the English translation of the chapter on colour reprinted in J.C. Taylor, *Nineteenth Century Theories of Art,* Berkeley, Los Angeles and London, University of California Press, 1989, p.470.

chemist, the effect always occurs naturally so the painter doesn't have to reproduce it on the canvas. Of great importance for artists was also a series of plates testing different combinations of colour harmonies with black, white and grey (Plate 8). These plates have been considered one of the sources of the dot strokes adopted by Neo-Impressionist and Divisionist painters.

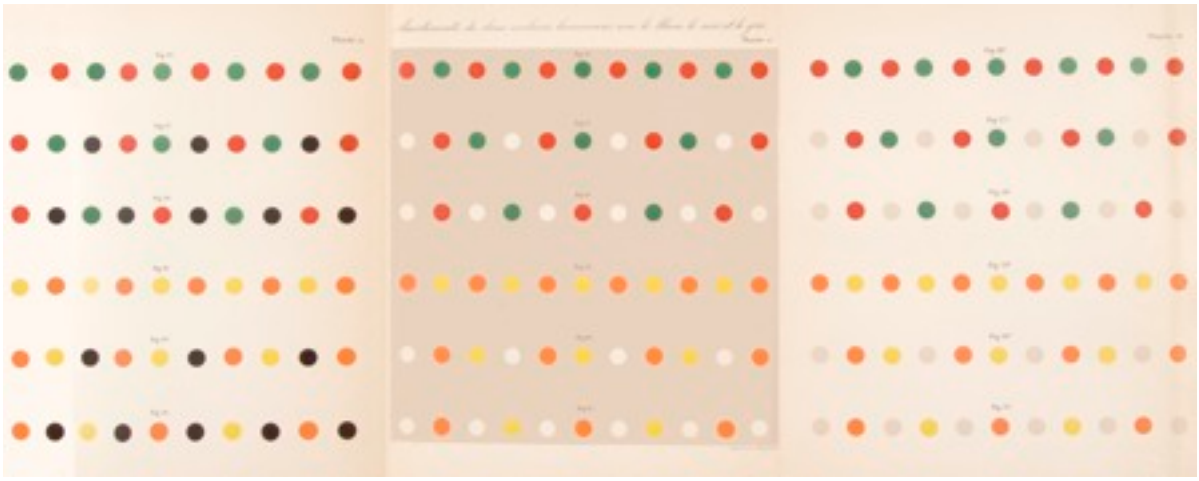

Plate 8: Combinations of simple and binary colours of the artists with white, black and grey, from *De la loi du contraste simultané des couleurs & etc.*, M. E. Chevreul, 1889.

Generally speaking, many factors explain the enormous interest provoked by Chevreul's book, and by the lectures he gave some years before its first publication in 1839. First, by dedicating a copious volume to this matter, he gave wide public access to phenomena until then discussed only in specialised scientific journals. Then, by meticulously studying the applications of his law to almost all the fields of art and crafts (from museography to horticulture, from army uniforms to stained-glass, from painting to tapestry, as well as framing and teaching), he moved from pure science to applied science, and addressed himself to almost all those who use colour.

Finally, he was not as interested in the production of "accidental" colours by the eye as in the mutual and simultaneous influence that two colours placed side by side exercise over each other, which was exactly the situation painters and tapestry-makers were constantly confronting. Hence their fascination for the law of simultaneous contrast. However, Chevreul's reception by artisans and artists has changed according to the evolution of artistic concerns. We can roughly distinguish five different stages.

a) First reception

Chevreul's theories of colour already had an impact before the publication of his main book, because of the influence of the public lectures he gave starting in 1830. Interestingly, the early reception of his theories was not by artists, but by artisans as well as people working in applied arts, decorative arts and industry. For example, a manufacturer of wallpapers decided to publish an album of coloured plates in order to demonstrate the contrast of simultaneous colours because he had realised that the first audience of Chevreul's lectures

regretted that no plates were available in order to illustrate the theory promoted by the great chemist. All these practitioners of colour were so interested because the knowledge of Chevreul's law allowed them to solve practical problems, such as the legibility of lettering on a coloured ground. This tendency, which concerned mainly professions involved in colour practice (from shop signs to gardening, or from stained-glass windows to silk manufacturers), also included theoreticians like Owen Jones who came to Paris in June 1836 to meet Chevreul; his *Grammar of Ornament* (1856) owed a lot to the law of simultaneous contrast.

b) Colour enhancing

At the end of his long life, Chevreul bitterly complained that the painters with whom he was in contact were not interested at all by his discoveries (Louis Hersent, Paul Delaroche, Hippolyte Flandrin). Even Horace Vernet, who visited Chevreul more often, did not take advantage of the law of simultaneous colour. Why, unlike colour practitioners in the field of applied and decorative arts, did these painters ignore Chevreul's teachings? Probably because they trusted their eye in their way of rendering nature, so that they were reluctant to accept, for example, that a long contemplation of the colours of the model, instead of helping them to reproduce it more accurately on the canvas, would produce, on the contrary, a complementary afterimage of the dominant hue!

Up to the 1880s, the only painters interested in Chevreul's colour theory were those who wanted to enhance their colours and they adopted accordingly what they called erroneously "the law of complementary colours". They were actually looking for a recipe in order to give more intensity to their colours, and found it in the juxtaposition of complementary colours.

Plate 9: Chromatic triangle of Eugène Delacroix, 1834, from a sketchbook belonging to Condé Museum, Chantilly.

We can understand now, at least partly, the huge impact Chevreul had on painters, due to the importance of the law of simultaneous contrast for colour harmony. As so many painters were trying at the time to enhance their colours,

this law provided them with an extraordinary technique. The other reason is that painters were anxious about colour harmony, and Chevreul, who had great prestige as a scientist, provided them with rules for colour harmony. By the way, the French title of his celebrated book -- *On the law of Simultaneous Contrast of Colours and on its Application* -- is not very appealing. Probably for this reason, the translators of the book into German and into English put forward the idea of colour harmony, an idea absent from the title of the original book published in French.

Amongst painters interested in enhancing their colours through juxta-position of complementary hues was Delacroix. We know through the testimony of Signac, the neo-impressionist, that he was very interested in Chevreul's theories. When Signac met Chevreul, he asked him about Delacroix, and Chevreul explained that he had once received a letter from Delacroix asking for an appointment, but unfortunately Delacroix cancelled, due to a cold.[13] However, in order to understand Chevreul's law Delacroix purchased notes made by someone who attended Chevreul's lectures.

Plate 10: E. Delacroix, *Entry of the Crusaders into Constantinople*, 1840, oil on canvas, 410 x 498 cm., Louvre Museum, Paris; detail - see text.

Delacroix made a mnemonic drawing of the complementary colours (Plate 9) he used for harmonising colours in his painting. According to Lee Johnson, the greatest expert on Delacroix, the *Entry of the Crusaders into Constantinople* (Plate 10) "would have served admirably as an illustration to Chevreul's book".[14] Indeed, Delacroix used his colour triangle to elaborate the composition which is

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[13] P. Signac, *D'Eugène Delacroix au néo-impressionnisme,* Paris, Hermann, 1964, p.76.

[14] L. Johnson, *Delacroix,* New York, W.W. Norton & Company, 1963, p.72.

structured by three pairs of complementary colours, in particular in the flags: one is yellow on a violet ground; another is blue with orange motifs, and finally on the floor there are two juxtaposed flags, one green and the other red. Unfortunately the colours of the painting have suffered dramatic changes, so that this effect is no longer visible, except for the two tangled flags on the floor. Interestingly, different spectators left a testimony of how Delacroix's paintings had changed during their lifetime, like Renoir, for instance, who could compare his memory of the paintings he saw in his youth with their deterioration when he was an old man. He said that when he saw them so badly damaged, he started weeping.

Plate 11: Claude Monet, *Poppies at Argenteuil*, 1873, oil on canvas, 50 x 65 cms, Musée d'Orsay, Paris.

If in some cases – Neo-Impressionism, for instance – Chevreul's influence is well documented and widely accepted, in other cases, like Impressionism, the situation is more complex and controversial, because of the seductive idea that Impressionist painters didn't need any theory, since they just trusted their eyes. I have addressed elsewhere this myth of a 'savage eye' that would have enabled them simply to copy what their eyes 'saw'.[15] Insofar as they wanted to enhance

[15] See my paper « Chevreul and Impressionism : A Reappraisal », *The Art Bulletin,* LXXVIII, 1, March 1996, pp.25-39.

their colours, they used the law of simultaneous colours that they applied in numerous paintings. This is in particular the case for Pissarro, the most interested in colour theory amongst Impressionist painters. After meeting Pissarro, a critic, Georges Lecomte, wrote that "At the 1877 Exhibition, M. Pissarro, applying in its rigorous logic the law of complementary colours, set his canvases into white frames that, without influencing the colours, left the tones with their exact values."[16]

Chevreul had actually drawn attention to the influence of the colour of the frame on the colours of the framed work. He had argued against the use of gilded frames: if the work itself includes golden elements, for example, the comparison between the golden frame and the golden parts of the painting would be unfavourable to the latter. The Impressionists followed his advice. Since Chevreul was probably the only scientist to have paid attention to this problem at the time, Pissarro could not have learned it from any other source. Three years later, Pissarro, who wanted to enhance the colours of his paintings, tinted "his stretchers with the complementary of the dominating colour of the painting".[17] This was indeed an excellent way of generating greater chromatic intensity.

Pissarro is not the only Impressionist painter to have used the harmony of complementary colours in order to give more intensity to his colours. It is also the case for Monet, who also liked to juxtapose complementary colours for the same reason, even though he claimed that he was reluctant to 'theorise'. This is particularly obvious in the case of his predilection for the poppy fields, which gave him the opportunity to oppose spots of pure red against the dominant green (Plate 11). Furthermore, Monet knew very well, as he himself explained in an interview, that "primary colours look brightest when they are brought into contrast with their complementaries".[18] This interview is additional evidence that confirms the conclusions of a close scrutiny of the paintings: the Impressionist painters were aware of the law of simultaneous contrasts of colours (as it was understood at the time) and applied it very often in their works in order to give them more intensity.

c) Neo and Post-Impressionism

During the 1880s, the artistic problems that painters wanted to solve started to shift from faithful imitation of nature to an interest in the organisation of colours on the canvas, and in the subjective conditions of vision. As a consequence, there arose a renewed interest for Chevreul's law of simultaneous contrast, and artists themselves paid more attention to the phenomena of contrast.

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[16] G. Lecomte, *Camille Pissarro*, in *Les Hommes d'aujourd'hui*, vol. 8, n°366, 1890, n.p.

[17] *Ibid.*

[18] E. M. Rashdall, "Claude Monet," *The Artist*, ix, July 2, 1888, p. 195-97; quoted in Bomford et al., *Art in the Making: Impressionism,* London, The National Gallery, in association with Yale University Press, New Haven and London, 1990, p.88.

The Neo-Impressionists painters were probably the artistic movement most interested in colour science.[19] Indeed, the artist and theoretician of Neo-Impressionism, Paul Signac, visited Chevreul with a fellow Neo-Impressionist painter, Charles Angrand, in 1884, and the following year he went back to visit Emile David, Chevreul's assistant at the Gobelins, this time probably accompanied by Seurat. I won't concentrate on Neo-Impressionist painters, as their interest for Chevreul is well documented and acknowledged by the artists themselves: Seurat mentioned Chevreul amongst his sources and copied out in a sketchbook the six principles summarising the usefulness of Chevreul's law for artists (§335-340 of his book).[20] As for Signac, he explained that "he studied, in Chevreul's book, the laws so simple of simultaneous contrast".[21] Both painters frequently interposed small dots of complementary colours in order to increase the luminosity of their paintings. For example, in a detail from Signac's *Breakfast* (Plate 12), we can see orange dots in the bluish shade of the cup on the tablecloth; similarly, there are red dots amongst the green reflections of the saucer. They applied thus the principle known as 'optical mixture', since the dots, instead of being mixed on the palette, are supposed to fuse in the eye when seen at a distance, and thereby produce a third colour, different from the two juxtaposed hues.

Plate 12: Paul Signac, *The Breakfast*, 1886-87, oil on canvas, 89 x 115 cms, Otterlo, Kröller-Müller Museum. On the right is a detail from the whole work,.

The theory of optical mixture, as understood by painters, which suggests that it should be possible to achieve an additive-like mixture by juxtaposing pigments so that they mix in the eye instead of physically, has been a source of enduring confusion. The point that often eludes painters is that this type of optical mixture does not add together the luminous energies of the individual colours; it merely averages them. Furthermore, there is an inherent

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[19] On this topic may I refer to my paper, « Seurat and Color Theory », in P. Smith (ed.), *Seurat Re-Viewed,* University Park, PA, Pennsylvania State University Press, 2010, pp.43-64.

[20] See *Seurat,* exhib. cat., Paris, Réunion des musées nationaux, 1991, Appendix J, pp.438-39.

[21] P. Signac, *D'Eugène Delacroix au néo-impressionnisme, op cit.,* p.99.

contradiction, when painters wish to combine the two principles: complementary colours and optical mixture. In principle, both behave in the same way to enhance colours: they heighten hues in the case of juxtaposing complementary colours; they heighten luminosity in the case of optical mixture. However, painters were not aware of the fact that these principles correspond to two quite different perceptual situations. As explained earlier, the colour contrast mechanism only functions if the juxtaposed samples are big enough. When the juxtaposed zones are thin, exactly the opposite happens: instead of enhancing each other, to exaggerate their difference, they tend to 'assimilate', that is to produce visually a dirty grey. But if juxtaposing dots of complementary colours does not endow the paintings with more luminosity, how can we explain the great luminosity apparent in their paintings? An answer has been given by Bob Herbert: if the Neo-Impressionists paintings are indeed very luminous, it is because the dots are big enough still to be perceived at the normal viewing distance and hence the optical mixture doesn't work.[22] So it is precisely because the dots don't achieve a complete optical mixture that they retain their luminosity!

Plate 13: V. van Gogh, *The Sower*, 1888, oil on canvas, 32 x 40 cm, Amsterdam, Vincent van Gogh Foundation.

[22] R. L. Herbert, *Neo-Impressionism,* exhib. cat., New York, Guggenheim Museum, 1968, p.19, and *Seurat and the Making of La Grande Jatte,* exhib. cat., Chicago, The Art Institute of Chicago, 2004, p.114.

Perhaps less known is van Gogh's interest in colour theory and complementary colours. Not surprisingly, his use of colours has been more analysed by neuropsychiatrists and ophthalmologists looking for dyschromatopsies than by art historians, due to his supposed madness. For instance he has been diagnosed as having 'xanthopsia' or yellow vision.[23] But if he had a great liking for yellow, a quick look at his paintings shows that yellow rarely occurs alone: in most cases, it is opposed to violet as the composition is structured by an opposition of complementary colours. This is the case for *The Sower* (Plate 13); as van Gogh explained in a letter: "The picture is divided in two: one half is yellow, the upper part, the lower part is purple".[24]

It was through Charles Blanc's interpretation of Chevreul's colour theory that van Gogh got acquainted with the theory of simultaneous contrast. After reading Blanc, he was so enthusiastic that he copied out a long passage in a letter to his brother and eventually sent him the book. What is striking is that his use of complementary colours was systematic. Thanks to his detailed descriptions of the colours and colour combinations throughout his letters, we know how attentive he was to colour harmony. Here again, he leaned on Blanc (as did Seurat and Signac), who proposed different ways of using the harmony of complementary colours:

> If we place in juxtaposition two similars in a pure state, but of different degrees of energy, as dark red and light red, we shall obtain a contrast by the difference of intensity and a harmony by the similitude of tints. If we bring together two similars, one pure, the other broken, for instance pure blue and grey blue, there will result another kind of contrast that will be moderated by resemblance.[25]

Yet this is exactly what van Gogh did. As he explained in another letter:

> I have made a series of colour studies in painting, simply flowers, red poppies, blue corn flowers and myosotys, white and red roses, yellow chrysanthemums – seeking oppositions of blue with orange, red and green, yellow and violet seeking broken and neutral tones to harmonise brutal extremes. Trying to render intense colour and not a grey harmony.[26]

Even more interesting is the fact that he wished not only to use combinations of complementary colours for the purpose of harmony, but also to make them contribute to the meaning of the painting. A good example of this chromatic strategy can be found in his famous *Bedroom* at Arles (Plate 14), whose description is well known:

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[23] See W.N. Arnold and L.S. Loftus, « Xanthopsia and van Gogh's Yellow Palette », *Eye,* 5, 1991, pp.503-510.

[24] V. van Gogh, letter to Emile Bernard (letter B7) c. 18 June 1888, in R. de Leeuw (ed.), *The Letters of Vincent van Gogh,* Harmondsworth, Penguin Books, 1997, p.362.

[25] Ch. Blanc in *Nineteenth Century Theories of Art, op. cit.,* p.473.

[26] V. van Gogh, letter 359a quoted in *The Letters of Vincent van Gogh, op. cit.*, p.328.

> This time it's simply my bedroom. Only here everything depends on the colour, and by simplifying it I am lending it more style, creating an overall impression *of rest or sleep*. In fact, a look at the picture ought to rest the mind, or rather the imagination.
> The walls are pale violet. The floor – is red tiles.
> The wood of the bed and the chairs is the yellow of
> fresh butter, the sheet and the pillows very light lime green.
> The blanket scarlet. The window green.
> The washstand orange, the basin blue.
> The doors lilac.[27]

Plate 14: V. van Gogh, *The Bedroom*, 1888, oil on canvas, 72 x 90 cm, Amsterdam, Vincent van Gogh Foundation.

From this quote, we understand that the meaning of rest is attributed to colour alone. More exactly, it is given first by contrasts of simultaneous colours (violet walls vs yellow bed and chairs; red blanket vs green window; orange washstand vs blue basin). Now, insofar as he wished to 'harmonise brutal extremes', i.e. complementary colours, he also used the repetition of the same hue in different states, as recommended by Blanc: pale violet and lilac; red and scarlet, green and light lime green, etc. This would explain how van Gogh thought that he could suggest the idea of rest through a particular use of colour combination.

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[27] V. van Gogh, letter to Theo n° 554, in *The Letters of Vincent van Gogh, op. cit.,* pp.416-418.

d) The advent of abstract art

With the advent of abstract art, things changed again. Why could the old ideas of Chevreul be of interest for some of the pioneers of abstract painting? The reason is that Chevreul provided them with rules for organising pure relations of colours, and this was exactly what they needed. From this perspective, Chevreul's law of simultaneous contrast proposed a grammar of colours, a syntax of colour combinations as well as of their modifications when seen juxtaposed. This was very attractive for painters preoccupied with colour combinations independent from rendering nature.

An excellent case in point was Robert Delaunay, one of the pioneers of abstract art, who was fascinated by the ideas of Chevreul. He often refers to him as "the brilliant Chevreul" ("le génial Chevreul"). He realised indeed that the law of simultaneous contrast provided him with a kind a grammar with which to organize his compositions. In his notes, he insisted in several occasions that "colour simultaneity through simultaneous contrast […] is the only real way for constructing a painting".[28] Delaunay's ambition was to grasp and fix on the canvas colour vibrations in order to render what he called "colour movement", and he thought he could succeed in this task by using the different speeds of colour vibrations. In a somewhat obscure text, Delaunay explained that:

> … the multiple dimensions [of a painting] form groups, which are opposed or neutralized, colour being a measure of vibration of such or such intensity, given its neighbourhood and its surface, in relation to all the other colours. Such vibration of an orange, placed in the composition next to a yellow—these two colours being placed almost side by side on the colour diagram—their vibrations being therefore very close, vibrate very quickly. If, in the composition, there is a violet blue, this violet blue will form a vibration with the yellow orange: a much slower movement[29].

From a formal point of view, Delaunay therefore opposed groups of colours that vibrate quickly to groups of colours that vibrate slowly, in order to provoke colour movement. In other words, vibration does not refer to spectral wavelength directly, but to the location of the juxtaposed colours on the hue circle. According to him, complementary colours vibrate slowly and are therefore harmonious, while adjacent colours vibrate quickly. Here Delaunay borrowed from Rood (whom he frequently quotes) the idea of 'small intervals', i.e. colours close on the chromatic circle. In a comment on his first non-objective painting, *Disk* (1913) (Plate 15), he wrote something similar, explaining that in the centre there are dissonances, or quick vibrations of red and blue, while all around there are consonances or slow vibrations of complementary colours, in particular of red and green. According to him, it is the opposition between the two different vibrational speeds that gives the painting its dynamics and enhances colour movement. The scientific validity or otherwise of this concept of colour movement achieved through vibration doesn't matter. What

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[28] R. Delaunay, *Du cubisme à l'art abstrait*, ed. by P. Francastel, Paris, SEPVEN, 1957, p.159.

[29] *Ibid,* p.60.

matters is that the contrast of complementary colours was used by Delaunay as a starting point to structure pure colour relationships in his compositions, and as an attempt to infuse his paintings with the actual vibrations of light. The optical properties of colour vibrations were an excellent way of focusing, no longer on the object but on sensations produced by colour vibration in the eye of the beholder.

The Colour Group was refused permission to display this work on the internet: you can see images (inferior) of it by web searching or at:

http://xroads.virginia.edu/~MA03/staples/douglas/modern.html
http://www.flashcardmachine.com/art-history19.html
http://quizlet.com/5971250/art-history-1900-present2-of-11-flash-cards/

Plate 15: R. Delaunay, *First Disk*, 1913, oil on canvas, diameter 134 cm, private collection.

What has been said for Delaunay holds true, too, for colour music and the first attempts at abstract colour movies. The problems that confronted their creators were similar but included time: how to organise colour combinations in order to achieve harmony through time? Here the central concept was that of mixed contrast, which Chevreul defined as follows:

> The distinction of *simultaneous* and *successive* contrast renders it easy to comprehend a phenomenon which we may call the *mixed* contrast; because it results from the fact of the eye, having seen for a time a certain colour, acquiring an aptitude to see for another period the complementary of that colour, and also a new colour, presented to it by an exterior object; the sensation then perceived is that which results from this new colour and the complementary of the first.[30]

[30] M.-E. Chevreul, *The Principles of Harmony and Contrast of Colours, op. cit.*, § 81, Chevreul's emphasis.

Indeed, it was crucial for music colour as well as abstract colour movies to take into account the afterimages produced by persistence of vision and to use them as a syntactic way of structuring the successive sequence of colours. Not surprisingly, the pioneers of colour music and abstract colour movies used colour contrasts in order to organise the succession of colours on the screen. Most of them emphasised the importance of Chevreul's successive and mixed contrast for their works.

e) Colour teaching

As the 20th Century progressed, it became more and more difficult to trace Chevreul's influence, for many reasons, amongst which was the fact that Chevreul's treatise had been challenged by more recent theories. However, this doesn't mean that Chevreul's teachings were lost forever or of no relevance. On the contrary, they are still alive precisely in the field of colour teaching. Thus the interest in Chevreul moves again, in particular due to the impressive number of experiments as well the tireless tests of colour combinations he made. Already in the 1920s, Chevreul was the main source of Matiouchin's colour teaching at the Academy of Arts of Leningrad (Ghinkhouk). And the two main books still used nowadays in colour teaching also owe much to Chevreul. The first is *The Art of Colour* by Johannes Itten, for whom the effects of colour contrast formed the basis of colour teaching. Chevreul is quoted amongst his sources even if his book borrows more from Adolf Hölzel. The second book is *Interaction of Color* by Joseph Albers. When it was first published in 1963, Don Judd – an artist, by the way, very interested in Chevreul – wrote an extremely critical review. Its first paragraph deserves to be quoted as a way of conclusion, and because it is appropriate to leave the last word to an artist insisting on the pre-eminence of Chevreul:

> *Interaction of Color* is primarily pedagogical. It gives a general idea of what is known about colour, but is not an encyclopaedia of colour information. If only the simple existence of the information is considered, there isn't anything new. Most of it and more is in Chevreul's famous and influential book, published in 1838, [*sic*] which was important to the Impressionists and then to Delaunay and Kupka.[31]

[31] D. Judd, review of Albers' *Interaction of Colors,* in *Arts Magazine,* nov. 1963, reprinted in D. Judd, *Complete Writings 1959-1975,* Halifax, Press of the Nova Scotia College of Art and Design, 1975, p.102.

Further reading

A paperback edition of Chevreul's book is available in English: *The Principles of Harmony and Contrast of Colors and their Applications to the Arts (1855),* Kessinger Publishing LLC, Whitefish, MT, 2009.

Most of the information provided here has come from my book *Art et science de la couleur: Chevreul et les peintres, de Delacroix à l'abstraction,* 2nd ed., Paris, Gallimard, 2009. See also G. Roque, B. Bodo and F. Viénot (eds.), *Michel-Eugène Chevreul : un savant, des couleurs*, Paris, Muséum National d'Histoire Naturelle/EREC, 1997. John Gage's contribution to the latter has been reprinted in English as "Chevreul between Classicism and Romanticism" in his book *Colour and Meaning: Art, Science and Symbolism,* London, Thames and Hudson, 1999, pp. 196-200.

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Plates 1, 2, 4, 6, 7 & 8: courtesy of Colour Reference Library, RCA, London; photos by Dominic Tschudin.
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