CHAPTER 28

Synthesis of colour ideas

Introductory

The purpose of this chapter is to prepare for the chapter on practical applications (the final chapter in this volume) by providing a summing up of a selection of the ideas presented in the two books in this volume.

The ideas in question come from two sources namely the history of artistic thought and practice since the Italian Renaissance and the evolution of the science of visual perception from its origins in the middle of the Eighteenth Century to the present day. Before the arrival of this new science, artists following the lead of the "Venetian Colourists", had learnt a lot about painting effects of light in their paintings. They came to realise that mastery of these depended on controlling whole-field variations in lightness (tone/value). Their most important discovery was that the lightness in one part of the painting should never be the same as the lightness in any other part.

The new science provided three main insights. Of these two were available at the time of the Impressionists:

- *That colour is made in the head and that, as a result, we cannot trust our eyes to provide a stable, measurable visual reality.*
- *That the light reflecting off surfaces always includes a proportion light reflecting directly off the surface containing the full gamut of wavelengths.*

A third much more recent insight gave a new significance to the second.

- *That the eye/brain contains many different visual systems amongst which is one that separates out this reflected-light from body-colour. Without this separation the information contained in the light coming into the eyes from surfaces would remain jumbled up and much less useful. With it, the eye/brain can use the* ***body-colour*** *component to provide an independently varying modality of information for use in the multimodal* *processing upon which the classification of objects depends. And it can also use the separated out **reflected-light** to provide information about surface-solidity, surface-form, in front/behind relations and the quality of light in the environment (all four of which make key contributions to the nature of our visual experience).*

If the separation achieved were to be as clear cut as the above description suggests, the life of figurative artists would be greatly simplified, but it is not. The problem is that their eye/brain systems lead them astray in important ways. One of these concerns shadows and shading:

- *Even though shadows and shading are actually due to a drop off in the intensity of otherwise invisible reflected-light, the eye/brain computes them as regions of body-colour.[1] As a result of this neural system computing error, we see cast shadows and shading as a darker version of the colour of the surface upon which they are situated. If artists were to paint what they see, they would simply add black to the colour they were using for depicting the surface upon which the shadow is falling.*
- *The situation is complicated because there is always a small residue of the reflected-light profile containing wavelengths from across the entire visible spectrum that is not converted into body-colour and that, accordingly, remains invisible. Presumably it was because the Renaissance Colourists, like everyone else, could not see this that they made no effort to paint it. However, their omission was significant because it is the invisible residual reflected-light which provides us with our sense of surface solidity.*

But how can artists represent what they cannot see in their paintings? The answer is simple: by subtly graduating the shadow colours using complex paint mixtures containing some proportion, however small, of pigment colour from both sides of the colour circle.

The separation of body-colour from reflected-light can also simplify matters for artists. A seeming problem for them is that the wavelength combinations of the reflected-light coming into the eyes from one region of body-colour is never the same as that coming into them from another. The only way artists can represent the unvarying variety that results is by ensuring that no one paint-mixture is the same as any other. This would be a formidably difficult task if it were not for the invisibility of the reflected-light. The fact that it cannot be seen means that it does

1 *An analogous but opposite deception is wrought with respect to highlights, which are created by sudden increase in the intensity of otherwise invisible reflected-light.*

not have to be reproduced accurately, a fact that saves artists from the need to bother about its precise composition. All that is necessary is to ensure is:

- *That the colours being used are continuously being modified.*
- *That they are made of mixtures containing complementaries.*

To achieve this outcome, it is helpful to remember the rule that the more complex the mixtures, the greater the available range of differences. Translated into practical terms, this means the more parent colours used in the complex mixtures, the greater the chance of avoiding repetition.

MAKING PAINTINGS FROM OBSERVATION

A preliminary division[2]

Following the discovery of spectroscopy as a reliable method of analysing the absorption/reflection properties of surfaces, scientists were able to show that no two substances have the same absorption/reflection properties (the basis of what we see as *body-colour*). In other words, all the multiplicity of different substances in our visual world have their own characteristic body-colour. This rule of difference applies not only to strongly contrasting colours such as those of earth, leaves, skin and sky, but also to many subdivisions. Thus, there are different earths (for example, chalky, brown, yellow, red and black), different species and ages of leaves (producing greens, yellows, oranges, reds and browns), different skin-pigmentation due to heredity, history of exposure to the sun and many other factors (including blacks, browns, yellows, pinks and whites), and different colours of sky due to differences in atmospheric conditions and viewing position in relation to the sun (including blues, greens, violets, greys and whites). As the human eye is sensitive to well over a million colours we can be assured that any natural scene can be divided up into a very large number of visually distinct body-colours.

But this is only a small part of the variations found nature. To the differences due to the uniqueness of body-colours, must be added to variations due to surface-reflection. These can be small or large depending on various factors including:

- The degree to which light reflecting from the surface of the object being viewed interferes with the perception of its body-colour.[3] From acute

2 See also "*Introduction to Science*".
3 As illustrated in *Chapter 7.*

angles in relation to a predominant light source, this can be extremely small. From obtuse ones, the body-colour can completely masked out. In both cases the outcome will vary according to the degree to which the surface texture profile causes the surface to be glossy or matt.

- Effects of the *resolving power of the eye's inner crystalline lens* on the appearance of texture (physical or painted) when viewed from different distances.
- The consequences of any variability in the extent or density of the atmosphere between the eye and the surface (aerial perspective).

- The outcome when any two surfaces or any two parts of the same surface of the same body-colour are illuminated by light sources with different intensity profiles and/or composed of different wavelength combinations. The most evident natural example of this difference is when one part of a surface is in bright sunlight and another part is in shadow and, accordingly, illuminated by much less intense secondary light sources. However, because all surfaces, are normally illuminated by a mind-boggling large and totally unpredictable complexity of secondary light sources, the profile of the reflected-light coming back into the eyes from any one surface can be relied upon to be different to the profile of the reflected-light coming back into the eyes from any other surface. Moreover, whether the differences are great (as due to contrasts between sunlit surfaces and cast shadows) or small (as due to scarcely perceptible variations of the hue, saturation and lightness of sum of the light sources), they will have an effect on the way we experience body-colours.

It is this combination of the multiplicity of body-colours and the possibly infinite variations of reflected light that lies behind the assertion of Professor Bohusz-Szyszko that no two colours in nature are ever the same.

Getting down to work

The time-honoured, academic method of making paintings required artists to produce a detailed drawing of their intended composition on the basis of preliminary sketches and the studies. The outlines of the figures and objects were then transferred to the actual picture-surface and filled in with unmodulated body-colours. For example, a region destined to become a blue dress might be painted as a uniform blue, or one that was to become a red curtain, as a uniform red, although there was no rule to say that its colour must correspond to that of the final figure or object. For example, a careful look at *Figure 1* shows that Piero della Francesca used red when under-painting the mid-blue dress worn by the right hand side angel, the purple dress worn by the middle angel and the dark blue dress worn by the Virgin Mary. Presumably he did so because he found that it has an important influence on the final look of the blues and the purple he glazed on top of them.

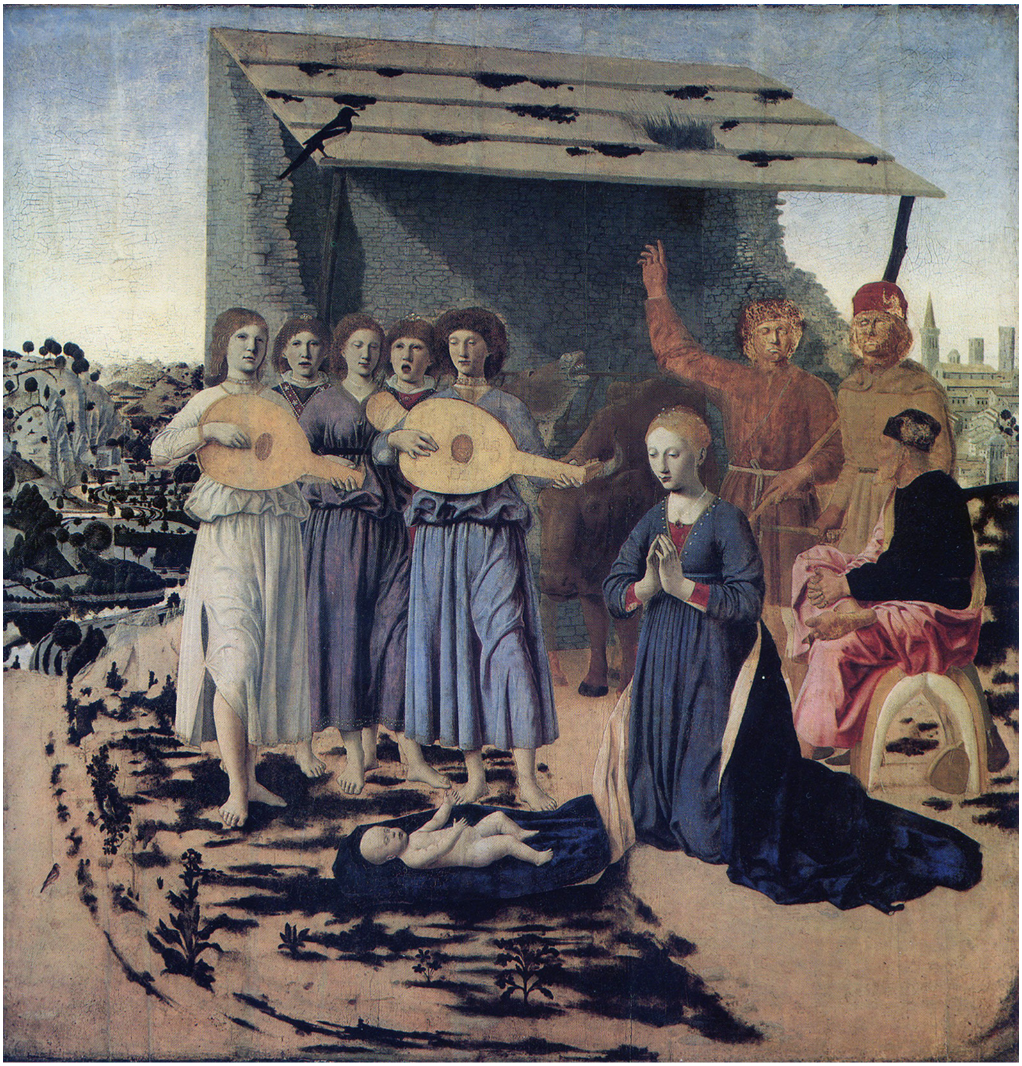

Figure 1 : Piero della Francesca - "Nativity".

According to the teaching of the academies, the depiction of lightness variations (tone, value) were to be achieved by adding graduated glazes to the flat colours of the under-painting. Although, when creating these, artists might use mixtures between pigment-colours that are adjacent on the colour circle, it probably never occurred to them that there might be an advantage in using ones from the opposite side of it. To achieve graduations, they simply mixed their base colour with varying proportions of black (or dark earth colours), grey or white.

While this lightness-based approach proved its value in the hands of the *Renaissance Colourists* and their successors (Titian, Vermeer, Rembrandt, Ingres, Turner, etc.), Seurat's science-based efforts to "*paint with light"* not only revealed its limitations, but also suggested exciting new possibilities.

Local and whole-field lightness relations

Representing the lightness relations between all the different regions of colour on the picture surface is no easy matter. This is why a preliminary stage required by the academic method was to produce a "*cartoon*" (a large achromatic drawing in which the totality of the lightness relationships are mapped as accurately as possible). As explained in earlier chapters, the considerable difficulty of pinning down these relationships lies in the shifting sands of appearances due to the eye/brain's way of processing information. The two main problems are (a) the exaggeration of lightness-contrast at the common borders of adjacent regions of different colour and (b) the loss of sensitivity to difference due to the recalibration of the lightness estimating visual systems that occurs with every new act of looking. From the practical point of view the outcomes of these very different kinds of perceptual distortion are that:

- The difference at the common edge between adjacent colours is exaggerated ("*simultaneous lightness contrast"*).
- The difference between separated colours is reduced ("*lightness/colour constancy"*).

As explained with reference to ***Mach bands*** in *Chapter 25,* exaggerations of differences at the common edge between adjacent colours can play havoc with the analysis of whole-field lightness relations and create a "quart into the pint pot" or visa versa situation. In contrast, the reduction of differences between separated colours has the effect of squashing lightness/colour space to the degree that artists see colours as the equal lightness when they should be different.

One way of minimizing these ever present perceptual problems is to follow the academic method and divide up the picture-surface into regions of flat, ungraduated colours (for example, *red* for a Piero della Francesco's angels in *Figure 1*), a process that involves ignoring both shadows and shading. The outcome will be an array of flat colours in which repetitions only occur where two or more regions of the same flat colour are separated from one another. Later on, differences can be introduced into these, corresponding to the ***shadows*** and ***shading***.

Stage 1: the relative lightness of different body colours

Figure 2 : Seated man in white shirt

Figure 2 allows a more detailed analysis of the above situation. If we look at the shirt and the trousers of the seated man, we find that the shirt is a different white than the trousers and lighter than it everywhere, except where there are shadows. As these are darker than the lighter parts of trousers, the situation can be described as a "*lightness crossover*" between the otherwise lighter shirt and the otherwise darker trousers. If we imagine removing all the shadows and shading, then there will be no such crossover.

If we now extend our search to the image as a whole, we find that the same rule applies throughout. If, after excluding the patch of highlight on the watch and the various shadows, we look at the shirt, the trousers, the hair and each of the different greys in the background, we find no crossovers between them with respect to the lightness of their body-colour. In other words, once shadows, shading and highlights, have been excluded no crossovers will ever occur. This even applies to the regions of different degree of skin pigmentation. Although roughly the same as each other, there will be no crossover between them. However, an artist mapping out the underpainting in terms of flat colours may choose to simplify matters by painting all the skin colours as being the same.

The next stage in the academic process is to rough in the shadows. Immediately the rule that there are no lightness crossovers between regions of different body-colour ceases to apply. As just pointed out the shaded parts of the shirt (otherwise the lightest colour after the highlight on the watch) are darker than unshaded regions of the trousers. They are also darker than the unshaded parts of the hair, parts of the wall, the arms, the face, etc..

Also important to notice is that are no crossovers between the levels of lightness in the shaded areas of any one body-colour. For example, although there is much similarity between the shadows on the two different forearms and the face, careful comparison shows that none of them is exactly the same as any of the others. The same applies to the shadows on the shirt. Perhaps the most difficult to see are the lightness differences in the darkest regions of the photograph. Only rigorously conducted comparisons, almost certainly involving much looking back and forth, will reveal them. A good starting point would be to try and identify the darkest colour in the scene. For example, we might consider the dark blue features at the extremities of the shirt sleeves and collar, the glimpse of chair-back against the lowest part of the shirt and the deeply shaded region in the bottom left corner of the image. The more we compare these with respect to their darkness, the more evident it is that not one of them is quite the same as any of the others. In the process of establishing this difference, the question as to which one of them is the darkest will have resolved itself.

Stage 2: lightness-contrast effects

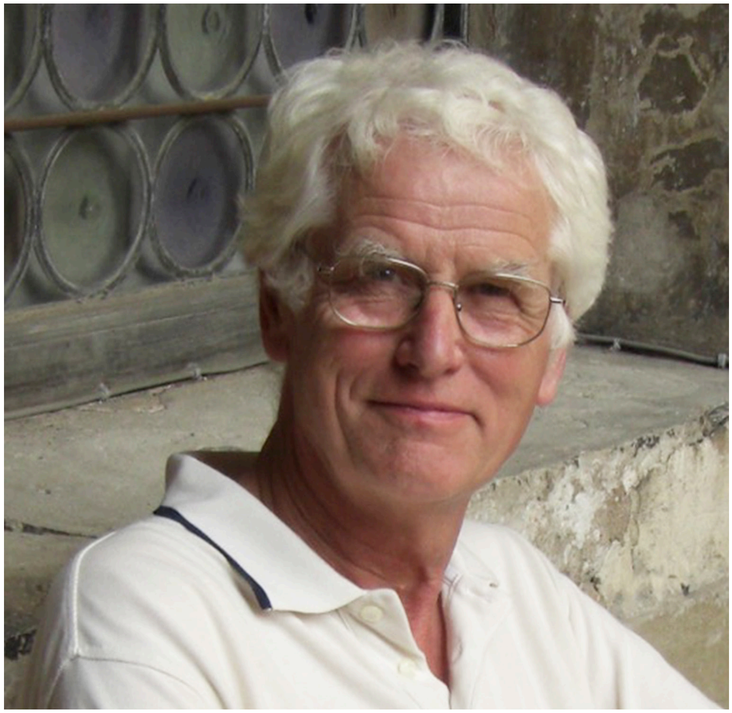

Figure 3 : Detail of Figure 2

Up to now matters have been oversimplified by ignoring the problem of *lightness-contrast effects* and it to these that we now turn.

It hardly needs pointing out that *Figure 3* is a detail of *Figure 2*. Notice that the darkest and lightest colours are now different. The biggest lightness contrast is between the shirt collar and the shadow on the neck. A slightly less dramatic one is between the back of the neck and the window sill behind it. Others are between the whitest parts of the hair and elements of the wall behind. In all these cases, as in many others, the juxtaposition of light and dark has the effect of making the lightness seem lighter and the darkness seem darker (the *Mach Band* effect).

A further complication has also been ignored. As explained in *Chapter 4,* lightness contrast effects are exaggerated when they involve thin lines embedded in strongly contrasting lightnesses. So, what does this tell us about the shadows in the creases on the face in *Figure 3*? How dark are they? Let us narrow our focus to this question.

Figure 4 allows us to focus down onto a number of such creases. Let us start with the near-vertical creases to the left of the mouth. Both the darks and lights are exaggerated by the lightness contrast effect. As a result, anyone could be forgiven for believing that the lighter parts are as light as the light regions to the right of the mouth. However, when measured with a light meter, they turn out to far from being so. Meanwhile the dark parts are subject to the reverse effect. In this case they could easily be taken as being as dark as the shadow on the neck when, according to the light meter, they are not even as dark as the more extended and soft edged shadow to their left, which is evidently lighter than the neck shadow. Another question that is difficult to settle by simple visual analysis is whether the shadow at the right had end of the mouth is darker or lighter than the creases that we have just been considering. I think that most people would see it as darker but the light meter says otherwise, making it if anything slightly lighter.

Figure 4 : Face creases

I could go on by asking which is lighter, the part of the neck adjacent to the white shirt collar or the subtle shadow on the side of the face adjacent to the grey window sill? Or, which is lighter, the shadow under the cheek to the right of nose or the subtle highlight adjacent to the left hand end of the mouth. According to the light meter the answer to both questions is that they are surprisingly similar.

Finally, it cannot be overemphasised that there can only be one darkest place and one lightest place in any natural scene. Keeping this truth constantly in mind can save artists from all sorts of problems. If we now go back to the image in *Fig-*

ure 2, we can immediately see how much lighter the darkest part of the neck is compared with the black chair back. Also it is easy to see that the highlight on the watch is much lighter than the lightest parts of the shirt. If we are going to get the whole-field lightness relations right, we will have to take these two extremes into consideration. If we do, we will find we have to paint many light areas less light than appearances suggest and many dark areas less dark than they seem to be.

Once we learn to perceive each region of body-colour as being different in lightness to all the other regions of body-colour and once we accustom ourselves to compensating for the exaggerated differences due to the lightness-contrast effect, we will find that our drawings and paintings look much more plausible. The only downside comes for artists who have been taking credit for producing portraits that come to resemble the sitter in later years. If they had followed the above suggestions they would assuredly end up with their models looking much too much like they actually appear to be at the time of posing.

COLOUR CONSTANCY AND EXPERIENCED REALITY

Colour constancy and ***lightness constancy*** were amongst the perceptual phenomena that towards the end of the eighteenth century persuaded scientists that colour is not a property of surfaces, but rather is an experience created in the head. Later they became of special interest of Hermann von Helmholtz, who published his synthesis of ideas about them in the 1860s, just in time to influence the young *Modernists Artist*s who were seeking ways to distinguish their figurative paintings from photographs. What the new knowledge showed them was that "***experienced reality***" is not at all the same as ***"measured reality***". And when they were considering how to represent it in paintings, the ideas about the constancies provided a main point of departure.

Colourfulness

A main characteristic of both lightness-constancy and colour-constancy is that of reducing the differences perceived in *measured reality* due to lighting and viewing conditions. To replicate this reduction, artists both suppressed modulations across regions of colour and lightened shadows. One consequence was that lightness differences between neighbouring colours were minimized, a change which had the effect of giving new force to colour-contrast phenomena. Two examples of this in paintings are *"L'Italienne*" painted by Van Gogh and the

"*Talisman*" painted by Paul Sérusier under the guidance of Gauguin (see *Figure 1* and *Figure 3 in Chapter 23*). With the passage of time, the idea took hold and Matisse (*Figures 5* and *7, below*), Bonnard (*Chapter 8, Figure 7*) and a host of other artists pushed the possibilities that opened up further and further.

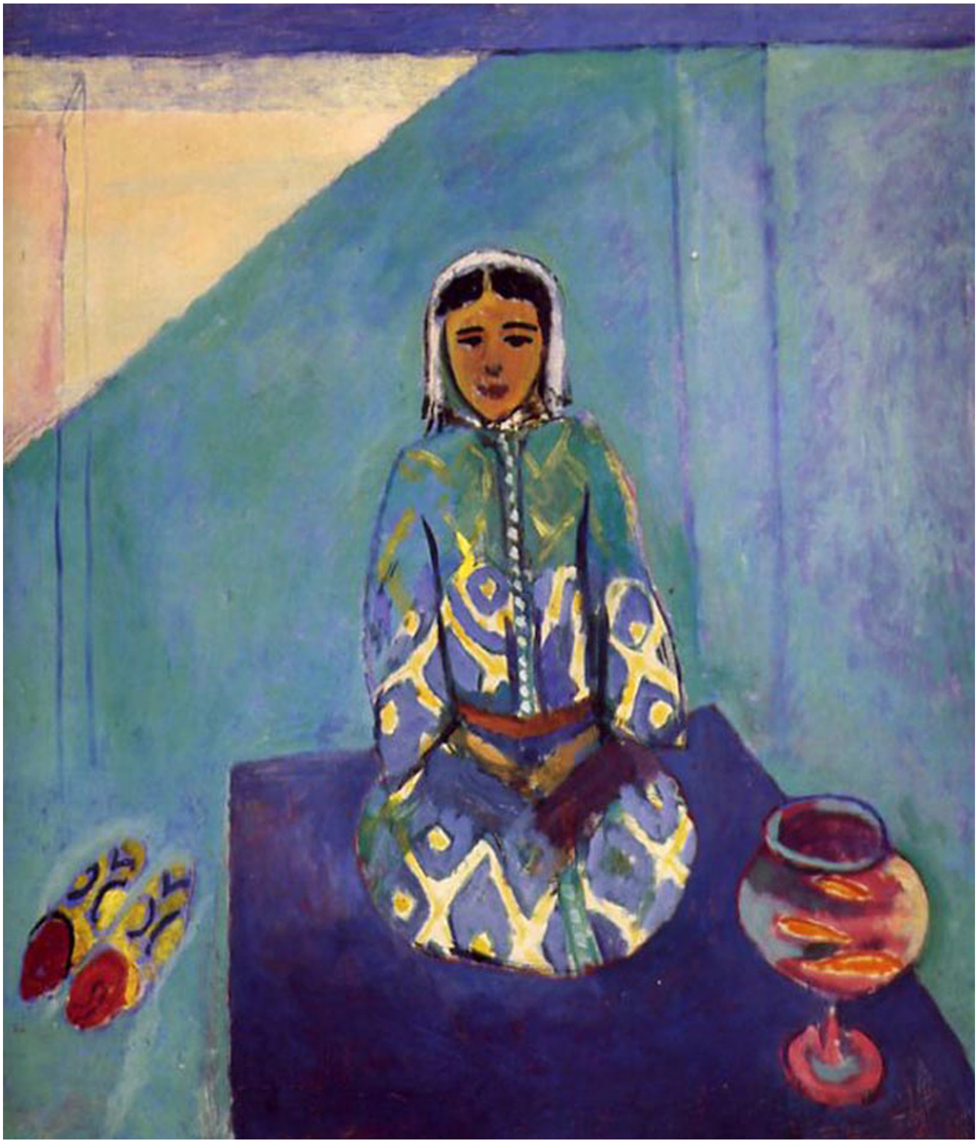

Figure 5 : Matisse - "On the terrace".

Figure 6 : Vermeer - "Lady reading a letter".

Compare any of these examples with the painting by Piero dell Francesca (*Figure 1*) or with the one by Vermeer (*Figure 6),* perhaps the greatest colourist amongst the old masters, and it is easy to see that the use of colour has entered new dimensions.

Simplifying

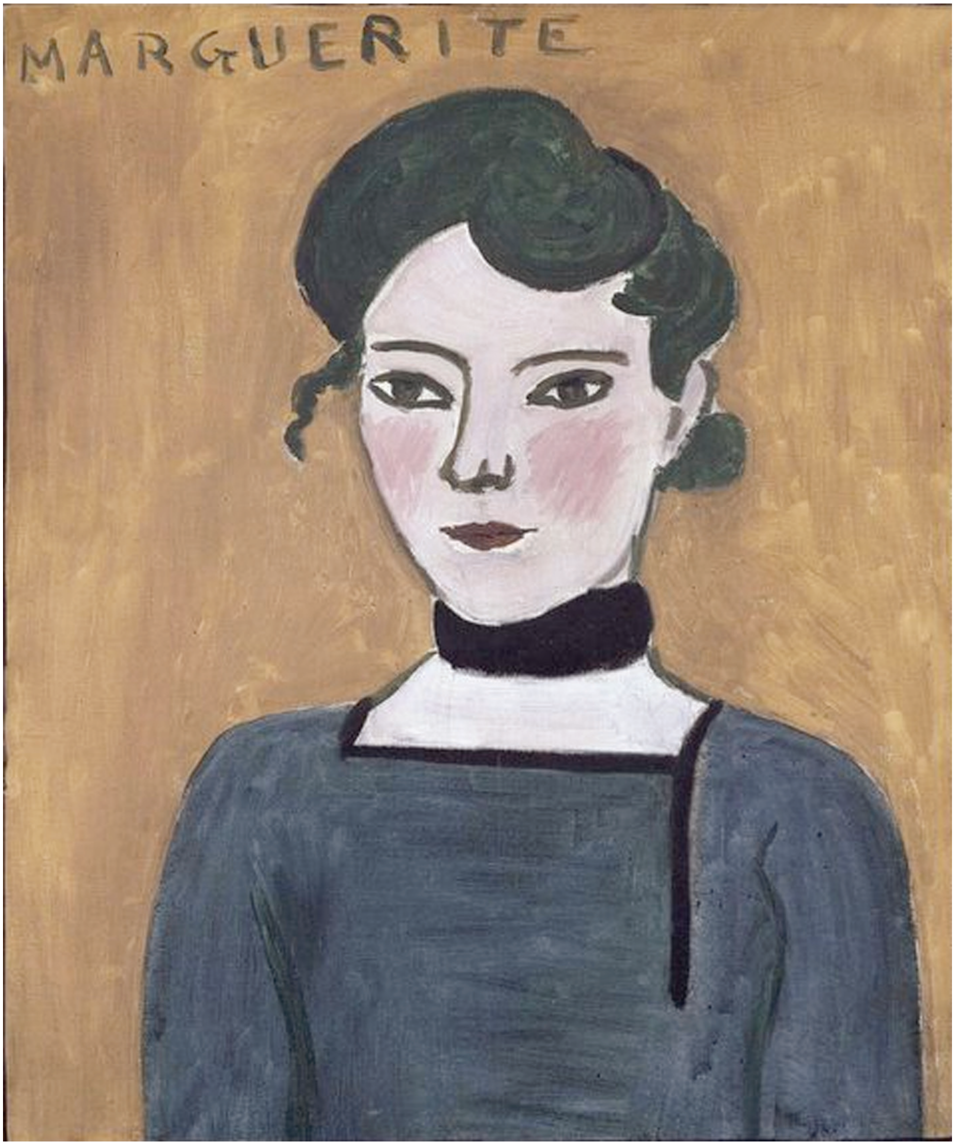

Figure 7 : Matisse - "Marguerite".

The *Modernist Artists* were also delighted to find that ironing out modulations across regions of body-colours had a simplifying effect. Even subdued ranges of colour were given a new force, as is illustrated by Matisse's portrait of his daughter Marguerite (*Figure 7),* which also shows how almost entirely removing the shadows and flattening out the colour can give portraiture a new power.

Surface, space and light

Three very important aspects of our everyday experience are our sense of

- Surface solidity.
- Space in front, between and behind objects.
- Light suffusing every scene

Yet, as explained earlier, essential parts of the information derived from the reflected-light, upon which our perception of these properties of appearance are based, elude conscious analysis. How then, we may ask, are artists supposed to set about the task of painting them? No wonder that they have welcomed the insights of scientists on the subject.

The situation would be worse if it were not for the computing error by which eye/brain visual systems regularly assess the magnitude of either the sudden increments in lightness that we see at the edges of cast shadows or the more gradual increments in the lightness that we know as *"shading"*.

This error allows artists to use:

- Cast shadows to provide cues that suggest pictorial depth.
- Shading to indicate surface-form.

All these factors were incorporated into painting practice by the time of the *Venetian Colourists,* who prioritised these invisible qualities of visual experience in their paintings. Perhaps their greatest contribution was the importance given to whole-field lightness relations and the consequent steps that they took on the pathway to the discovery of the rule that no two lightnesses in any one scene are ever the same.

By the time of Seurat, all the above ways of doing things were part of the established kitbag of artists' tools. Significantly, all of them had been included in it as a result of conscious visual analysis.

In contrast Seurat's way of ***painting with light*** was based on theory. He simply applied laws of physics that he had found in science books. It was because these were well founded that his *Pointillist* strategy worked as well as it did, and the reason why it was to have such profound ramifications. Later artists were likewise blindly following theory when they adopted a systematic inclusion of complementary colours in their paint mixtures. It is significant that my teacher, Professor Marian Bohusz-Szyszko, explained why they did so in terms of physics not of visual perception.

However, the Professor's test for the efficacy of his science-based teaching was whether or not it worked in paintings. The same is true of the science presented in this book. Amongst other things, it provides two reasons for always using complex paint-mixtures containing colours from both sides of the colour circle, namely that:

- Without the resulting complexity, the range of colours that can be made would be very much more limited, making it more difficult to obey the Professor's non-repetition rule.
- If colours are repeated, they will be perceived as attached to the picture-surface and, accordingly, will disrupt attempts to achieve a sense of an integrated illusory pictorial space and light.

Another finding of the science is that the three wavelength sensitive cone receptors, situated in the fovea that extract the information used by the eye/brain to create perceptions of ***body-colour*** are not the same as those used by it to deal with reflected-light and whole-field colour relations. They differ in at least two respects:

- Since they provide information from relations between regions of surface, as opposed to providing information uniquely from the most fully saturated regions within them, they must be dependent on ***extra foveal receptors***. Precisely which ones, we do not know. However they certainly include the large numbers of ***cone receptors*** that are scattered around in extra foveal regions and that respond maximally to the shortest wavelengths of the three types of cone receptor (usually referred to a the 'blue' cone receptor). Equally certainly, they include many, if not all, of the 150 million ***rod receptors*** which are maximally sensitive to slightly longer wavelengths (between blue and green).
- In addition they are also sensitive to the differences between inputs provided by at least three different sizes of ***receptive field***. ('***small***', '***'medium***' and ***large***'). This means that ***texture*** can be described as one of the primaries with respect to the perception of reflected-light and whole field colour relations. While it remains an open question whether information

derived from the other two cone receptors is involved in use of texture derived information, the existence of a texture-sensitive group of receptors allows artists to create achromatic illusory pictorial spaces in paintings using a combination of ***texture*** and ***lightness*** variations alone. What this means is that, although, since Seurat, we know that the appropriate use of ***complex colours*** will enhance the outcomes, there is no need to use them at all. This is why the academic approach based on lightness variations alone worked to the extent it did.

Significantly,This emphasis on the role of texture in creating effects of *light-filled, illusory pictorial space* in achromatic images does not mean that the Seurat/Cézanne/Bonnard complex-colour based approach to painting *light-filled, illusory pictorial space* has no value. Rather we can conclude the fact that it works. At the very least it allows for greater range of nuances and, therefore of lightnesses. To my eyes, by adding another layer of richness to the colour experience, it does much more than that.

Implications

*The purpose of this chapter has been to provide a reminder of various ideas from the first Book of this two-book volume,[4] that are pertinent to the exercises presented in the following three concluding chapters. One important idea that is still missing concerns **minimal cues** and an explanation of their significance in drawing and painting will provide a starting point for what follows.*

4 *"Painting with Light"*