CHAPTER 7

The perception of surface and interreflections

Introductory

As preparation for grappling with Georges Seurat's ideas about painting with light, it will be helpful to be clear about the role of reflected-light both in creating our sense of surface and in enabling our eye/brains to work out how surfaces relate to one another.

Light and surface

The ideas which follow concerning *surface-reflection* can be generalised for all surfaces including those of lakes (*Figures 1-4)*, of fields (*Figures 6-9)*, of all flat objects, such as books (*Figure 10)* and paintings. They also relate to inter-reflections between surfaces *(Figures 11-15)*.

Figure 1 is an image of a row of trees and their reflection in a lake. The water is mirror-smooth, with the trees and sky clearly reflected in it. Indeed the image is so clear that, if the picture is turned up-side down (*Figure 2*), the scene in the reflection is very nearly as authentic as when it is the right way up. Notice in particular that there is virtually no sense of there being a surface to hinder the notion of entering into the mirror-image space. Now imagine that the water has been agitated by a stiff breeze. The reflected image of the row of trees and the sky would be fractured and jumbled up and the expanse of water would become uniform in appearance (*Figure 3*). No trees are now visible in the water. What we see is a more or less uniformly coloured and more or less flat expanse of water. However, from a closer viewing position (*Figure 4),* it becomes evident that its surface is made up of little wavelets. Each of these combines regions containing a mosaic of reflections from a multiplicity of directions with ones that take their colour from the murky brown water that is visible between the wavelets. The fractured reflected light gives the expanse of water in *Figure 3* its sense of surface. The murky brown is what we can see of its *body-colour*.

Figure 1 : Smooth water surface giving mirror reflection

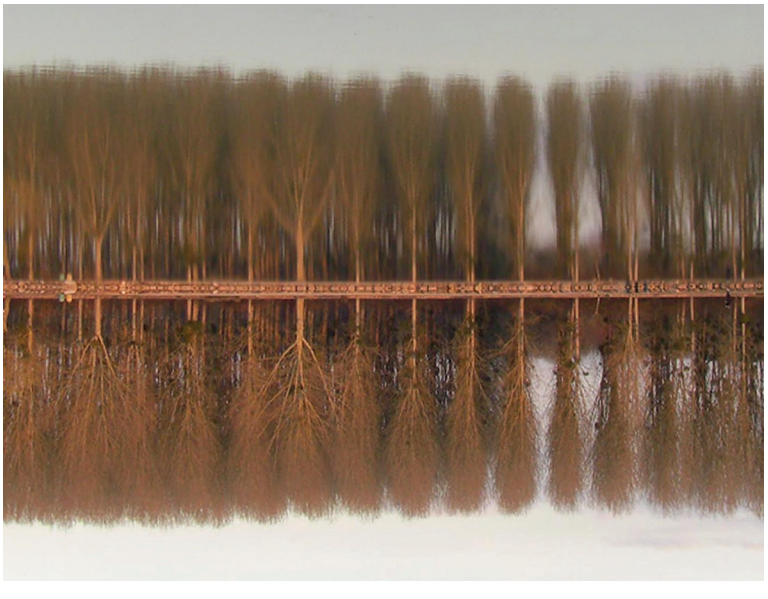

Figure 2 : Upsidedown version of Figure 3. The mirror image is almost as clear as the scene it is reflecting.

Figure 3 : Rough water surface giving "matt" reflection

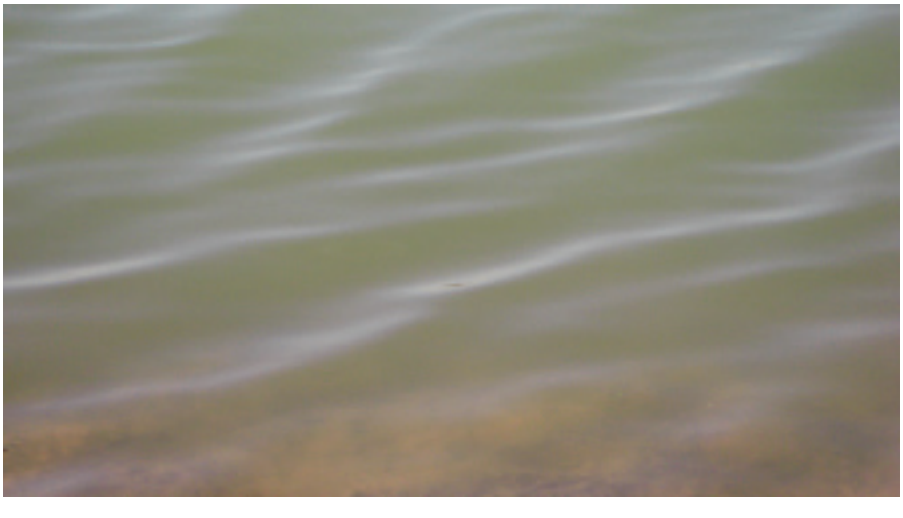

Figure 4 : Close up of the water in Figure 3 showing both surface-reflection and body-colour of water and lake bottom. Due to optical mixing, these blend into a unified colour (Figure 3) when viewed from a distance.

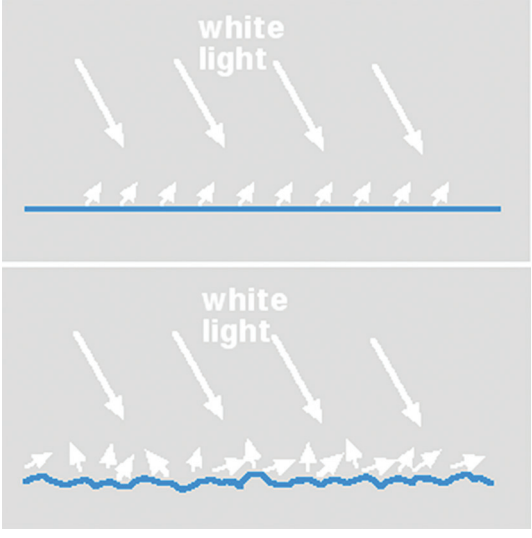

Figure 5: Diagram showing reflections from smooth and rough water.

The diagram in *Figure* 5 illustrates the two extremes. The top half represents the mirror-like surface of the lake shown in *Figures 1 and 2*, while the bottom half illustrates the light being scattered in all directions by the rough water, as in *Figure 3 and 4*. The crucial thing to notice is that, when a surface is mirror smooth, we do not see it as a surface whereas, when it is rough, we do. From this we can deduce that the ***sense of surface*** is provided by the myriad of mirror reflections in ***scattered-back light*** that are coming from just about every point of the compass. This confusion of tiny reflected-light sources, each with their own colour characteristics, will be optically mixed in the viewer's eye. In *Figure 3* the result is the almost uniform grey blue of the surface of the water. Only when the wavelength combinations coming from the different directions are sufficiently similar will the colour of the water correspond to a specific colour in the scene (as when the sea looks blue on a cloudless day).

If we move from side to side or from nearer to further in front of a mirror, changes occur in what is reflected in it. The same is true of movements in relation to the myriad of mirror reflections that characterise the broken up surface of the lake.. As we move our eyes across its surface, the composition of the light being reflected from it will change producing a seamless modulation in the optically mixed colour.

What applies to water applies to all surfaces

Figure 6 : Close up of a field - Looking into the sun.

Figure 7 : Distant view of a field - Looking into the sun.

Figure 8 : Close up of a field - Looking away from the sun.

Figure 9 : Distant view of a field - Looking away from the sun.

As suggested above, what applies to water applies to every surface. All are on a continuum from glossy to matt. In nature, the vast majority are matt. If so the ***fractured reflected-light*** will create ***optical mixtures*** tending towards achromaticity. *Figures 6-9* provide examples of the degree to which the appearance of surfaces can change as a result of being looked at from different angles relative to the direction of the main light source. In *Figures 6 and 7*, the sun is in front of the viewer and its light is being ***transmitted*** through the blades of young barley, which act as green filters, absorbing all but the wavelength combination that gives the particular green that we see. In addition, where the light has been blocked from coming through, shadows have been created. Accordingly, there are a multitude of relatively strong contrasts between the brightest and the darkest elements in the scene creating a heavily textured effect. In *Figures 8 and 9,* the sun is behind the viewer such that the purity of the green of the leaves is compromised by the large contribution from the ***reflected-light***. As a result the green of the barley leaves look much "*whiter*" (desaturated) than the green in *Figures 6 and 7*. Notice however that the combination of the body-colour and the reflected-light does not mean a diminution in lightness. On the contrary, the greens in *Figures 8 and 9* are a great deal lighter than the transmitted green in *Figures 6 and 7*. Also notice that the darkest and lightest parts of the scene are much less contrasted. The overall effect is that in *Figure 7* the field is perceived as being more fully ***saturated*** but darker, while in *Figure 9,* the green is a great deal more ***desaturated*** but considerably lighter.

Viewing angle and rectangular flat surfaces

Figure 10 illustrates the way I demonstrate to my students the importance of viewing angle on the appearance of a flat matt surface.

Figure 10 : A book with a matt red cover from four viewing positions showing a progressive change the visibility of the reflected-light.

On my bookshelf is a somewhat battered book with a matt red cover. Having placed this on the mantelpiece with the light coming in through the window to the left, I ask the students to move across the room from left to right in front of it, so as to look at its surface from different angles. The first viewing position (the furthest left image in the row) is slightly to the left of frontal, such that the angle between the main light source, (the window), the surface of the book and the viewers' eyes is very slightly less than 90°. As the students move towards their right, the angle becomes obtuse and then more and more so until the students are looking at the books side on (the furthest right image in the row). As can be seen from the four viewing positions illustrated, each move rightward results in the reflected-light becoming more evident and, in consequence, the body-colour being progressively obscured and the colour of the surface more desaturation. From this demonstration we learn the rule that to see the body colour of the book at its purest there must be an acute angle between our viewing position, its surface and the light source.

A similar rue can be applied to all surfaces, including multicoloured ones such as paintings. In every case the purity of their body-colour or colours is progressively desaturated as the angle between the main light source, the surface and the line of sight becomes more and more obtuse.

It hardly needs adding that it is the interests of both artists and viewers to find the viewing position from which the colours in paintings can be seen to their best advantage. More specifically this means ensuring that the angle between the main light source, the picture-surface and their line of gaze is less than 90°. As illustrated in *Figure 10*, it only has to be very slightly less to achieve the desired result.

Interreflections

Figures 11, 12 and 13 illustrate the phenomenon of interreflection. They can be seen as analogous to *Figures 1 and 3* with respect to the way that they illustrate the difference in the visibility of interreflections between an object situated on a glossy surface and the same object situated on a matt surface. In *Figure 11* the reflections of trees and the box are easy to see in the smooth lake and the silvery surface respectively. In contrast, in *Figures 12 and 13* the roughened surface of the lake and the matt surface on which the box is now placed, reflections are either very difficult or impossible to see

Figure 11 : Box on shiny silvery surface

Figure 12 : box on matt-white surface

Figure 13 : Box on matt-red surface

Moreover, looking at matters in a different way, it is not possible to discern the reciprocal reflection between the flat surface of the lake and the trees in *Figure I and 3,* and it might take a little time to detect traces of them in the surface of the box shown in *Figures 11, 12 and 13*. However if three images are compared, then it becomes clear that the colour of the front of the box is being influenced by the light being reflected back up from the supporting surface. Even then, the degree of its visibility depends on the surface of the box being slightly shiny.

Figure 14 : A Chinese ginger jar placed on 3 different surfaces.

The same points can be made by analysing the interreflections in *Figure 14*. In it the same Chinese ginger jar is placed on three different surfaces. Only when the surface is highly reflective (as with metallic surface) is the image of the jar visible. There is no trace of it on either the matt while or the matt red. However, since the jar is glazed, reciprocal reflections can be discerned on the lower part of its surface in all three cases. Once again, these are made even more obvious by making comparisons between the different images.

Figures 11-14 all illustrate cases of interreflections between two surfaces that abut one another. In some cases they are easily visible and in others impossible to see. However, whether they are visible or not, artists who are drawing or painting from observation would be well advised to take them into account. The reason is that the visual system that extracts information from reflected-light uses them to tell the eye/brain that the object is on the surface and not separate from it. It it is the ***interreflections*** that establish the absence or presence of ***connectivity***. As it were, they anchor the object to the surface upon which it is situated or, to put the same thing another way, they stop it from floating free.

Three significantly different types of border

Figure 15 : Card on matt red surface

Figure 15 is an image of a greetings card standing on a red surface. It has three kinds of border. They occur between:

- The base of the card and the supporting surface.
- The two sides of the vertical crease which separate the two differently oriented surfaces of the card.
- The card and the scene behind, including parts of the red surface.

Each of these borders provide different types of information for the eye/brain. As already suggested, the first indicates "*a support relationship*". The second indicates a "*change of plane*" while preserving connectivity, and the third indicates an "*in front/behind relationship*" that involves "*spatial separation*". One extremely important difference between the first and the other two is that it provides interreflections. The others do not.

Also worth noticing is that although there are no interreflections between the two faces of the card that are separated by the crease, both of them are influenced to some extent by the reflections from the red surface, a fact that contributes to the perception of the card as an integrated whole.

Visible and invisible effects of light

As the various illustrations should make clear, some of the above effects of light on surfaces are clearly visible, others are only too easy to overlook and yet others are completely invisible.

Even within the *clearly visible category*, ***comparisons*** between the surfaces in question may be required to bring the interreflections to awareness. In the *easy to overlook* category they are essential. To give some examples, **same/different** judgments will reveal telltale differences between:

- The front face of the box situated upon three different coloured surfaces in *Figures 11, 12 and 13*,
- The bases of the three ginger jars in *Figure 14* and the three different coloured surfaces upon which they have been placed.
- The two identical bands of metallic grey pigment at the top and bottom of the left hand side of the card in *Figure 15. N*otice that a main reason for the colour difference between them is that the two bands are at two different distances from the red surface upon which the card is standing..

It hardly needs adding that within the *invisible category* there is no possibility of consciously seeing the interreflections.

However, whether ***visible*** or ***invisible***, the reflected-light gives the eye/brain information that it uses in the perception four of fundamental qualities of appearance namely:

- Surface.
- Interconnectivity between surfaces.
- In front/behind relations.
- The quality of the light that permeates the whole-scene.

One way we showing that the eye/brain makes use of surface-reflection of which we have no conscious awareness comes from experiments that show that important changes in how we perceive paintings can be made by additions of

complex mixtures of pigment colours that are so diluted that they cannot be seen. More on this in *Chapters 9 and 10.*

Implications

The purpose of this chapter has been to:

- Illustrate how: the nature of surface-reflections vary according to differences in the *smoothness* and the *roughness* of surfaces; how smoothness corresponds to "*glossy*" and roughness to "*matt*"; and, how all surfaces can be categorised in terms of these two properties.
- *To emphasise that the vast majority of surfaces are at the matt end of the matt/glossy continuum.*
- *To explain the role of viewing angle in determining the degree to which surface-reflections interfere with the perception of body-colour.*
- *To show examples of interreflections and to give substance to the idea that, whether visible or not, they are very important in visual perception because of their role in establishing the presence or absence of interconnectivity between surfaces.*

The next chapter explains the method that Seurat developed for depicting reflected-light in all its manifestations.