More than colour – dimensions of light and appearance

Paul Green-Armytage

University Associate, School of Design and Art, Curtin University, Australia
Email: p.green-armytage@curtin.edu.au

This article is about seeing, thinking, and new possibilities for art and design. The relationships between light and the different aspects of appearance are not well served by our language or by existing models. The article deals with the different modes and different aspects of appearance and presents a new model for showing relationships between light and objects that are more or less transparent, more or less glossy, more or less metallic and textured in some way. Each point in the model can connect to a colour order system. The model is a conceptual framework for a better appreciation of appearances that can be a thinking tool for artists and designers.

Received 27 October 2015; revised 05 May 2016; accepted 19 May 2016

Published online: 11 January 2017

Introduction

It is possible to compose music without understanding the conventions of music notation, but notation opens up a much richer musical world. With notation a piece of music can be recorded and analysed, and it can be performed by people other than the composer in a different time and place. An understanding of music notation can also make a person more conscious of musical possibilities and it is a powerful tool for the creative process.

Notation systems for architecture, and for the visual arts in general, are more limited. We have the conventions of geometry and we have colour order systems, but there are many aspects of appearance, that are beyond geometry and colour, that contribute to the overall impact of a work of art or design. The role of light can be critical. An object may be red but it will also be matte, glossy, metallic or textured and, in a given context, may appear transparent or translucent. Then, while individual elements in a work of art or design play a role, it is how the elements are related in the whole that ultimately matters. I have discussed this topic before [1-3] and I showed *A Model to Link Different Modes and Different Aspects of Appearance* in a paper presented at the AIC Midterm meeting in Zurich in 2011 [4]. This article is an elaboration of that paper. I will discuss the dimensions of light and appearance and will present a revised version of the model presented in Zurich with new illustrations. The intention is that this model may play a role similar to that of music notation, especially for expanding awareness of possibilities and as a creative tool.

Visual experience

Visual experience is our main source of information about our surroundings but extreme conditions can make us blind. In the following story the visual experience of an airline pilot was reduced to a single element. It is a terrible story: On the 28th of November, 1979, an Air New Zealand plane carried a party of tourists on a sight-seeing trip to Antarctica. The plane flew low under the clouds, through clear air, straight into the side of mount Erebus. All 257 people on board were killed. There was a Royal Commission of Inquiry into the disaster presided over by Justice Peter Mahon. It was found that the airline had changed the computer track for the aircraft without telling the crew. For the route shown by his instruments the pilot was flying safely over level ground, but he was flying blind. He could see nothing ahead but whiteness. There was no contrast between the cloud above and the snow below and nothing to reveal the rising ground ahead. It was a condition known as 'whiteout' – like being inside the integrating sphere of a spectrophotometer. In his report Justice Mahon pointed to the mistake made by airline officials which had combined, to deadly effect, with what he called 'a malevolent trick of the polar light' [5].

The kind of conditions faced by the pilot of Air New Zealand flight 901 are described by Peter Kaiser and Robert Boynton as 'a limiting case of spatial vision referred to as a *ganzfeld*, which is achieved by filling the entire visual field with light that is uniform in both luminance and chromaticity.' [6]. Kaiser and Boynton describe a way of experiencing such a ganzfeld (p.357). Cut a ping pong ball in half and place one half over each eye, keeping the eyes open. Then face a uniform coloured light. Soon the colour will fade but it will return if you blink. Apparently you will begin to hallucinate if you keep your eyes covered like this for long enough.

It is possible to experience a near ganzfeld without resorting to the ping pong ball trick. Figure 1 is a photograph taken on a ferry sailing in the fog between Prince Edward Island and Nova Scotia. For the photograph in Figure 2, I lay on my back in the middle of a field on a cloudless day and photographed the sky overhead. The photograph in Figure 3 was taken inside *Colourscape*, presented by artists Peter Jones and Lynne Dickens at the Perth Festival in 1981. My friend was wearing a green cloak and was sitting in a compartment of *Colourscape* that was made of translucent red vinyl. The light from outside was filtered by the vinyl and then reflected back and forth within the space. This had the effect of increasing the intensity of the red so that when I entered the compartment it seemed as though the space was filled with a red mist. I might have been rendered as blind as the pilot of flight 901 if my friend had not been sitting there to provide the contrast. His green cloak absorbed much of the 'red' light so that his cloak appeared dark. Had he been wearing a red cloak I might have seen nothing but his face outlined by his hair and beard. Just as the presence of my friend provided the contrast that made it possible for me to see where I was going inside *Colourscape*, an outcrop of dark rock on the slope of Mount Erebus might have revealed the danger and enabled the pilot to fly clear.



Figure 1 (left): Photograph taken on a ferry sailing in the fog between Prince Edward Island and Nova Scotia.
Figure 2 (middle): Photograph taken of the sky on a cloudless day while lying on my back.
Figure 3 (right): Photograph taken inside Colourscape.

These examples may be interesting, but it is possible to experience a ganzfeld whenever you like. Just close your eyes. Although you can no longer see anything you will still be having a 'visual experience'. In fact it is possible to see objects of a kind with your eyes closed, objects in the form of after-images. I had a photograph of a red rose on my computer screen and stared at it for about a minute and then closed my eyes. I experienced an after-image. I 'saw' a dark turquoise shape against a dark reddish background. (Note: This will work best with a high intensity image, preferably a source of light such as from a computer screen.)

Even though we are familiar with the experience of having our eyes closed we do not normally include that as part of our visual experience of the world around us. We see the sun, the sky, the sea, trees, rocks, buildings, people. But John Ruskin reminds us that it is only from experience that we read our surroundings in this way: 'Everything that you can see in the world around you, presents itself to your eyes only as an arrangement of patches of different colours variously shaded. The perception of solid Form is entirely a matter of experience.' [7]. A single patch of colour, if it fills your field of view, is not enough for the perception of form, as anyone who has experienced whiteout, or any other kind of ganzfeld, would know. We need more than one patch and we need contrast.

Single colours and colours in combination

Most attention in colour research has been devoted to isolated colours. Physicists have studied individual sources of radiant energy and uniform surfaces which absorb and reflect the different wavelengths of light. Physiologists have studied the sensitivity of the human eye to these lights and surfaces. Psychologists have solicited responses to individual colour chips – are they beautiful or ugly? old fashioned or modern? warm or cool? This work has made it possible to draw all kinds of conclusions about the nature of things and the workings of the human eye and brain. It has also made it possible to produce and reproduce coloured images and to match the colour of one material with that of another. And it has provided some useful guidelines for designers. But for the most part this has been study of what is essentially an artificial world. Not only do coloured surfaces have different qualities and different textures but we hardly ever experience them in isolation. The appearance of things changes as time passes and we move about. Appearances change as relationships change. The context in which things are seen can have a profound influence on how they are perceived.

Between 1985 and 2001 I had many discussions with Western Australian artist Howard Taylor. Taylor objected to my work with colour chips. In one of his letters to me, quoted by Gary Dufour [8], he wrote: ‘An isolated colour or other element is a specimen only – an I.D. card’. In that letter he stressed the importance of contrast as it applies to all pictorial elements. During my visits to his studio he showed me examples of his work to illustrate what he meant (Figures 4-6).

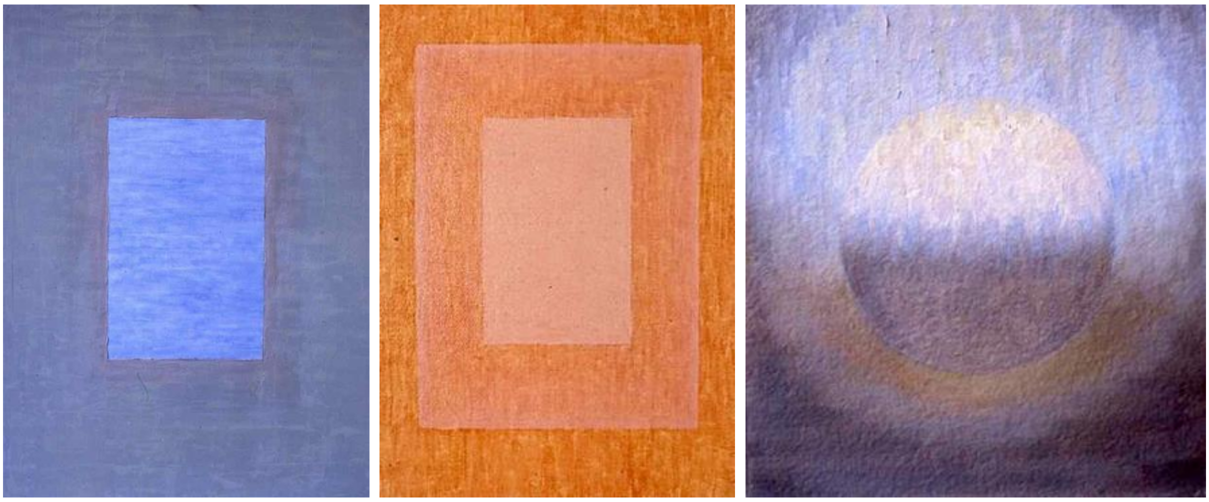


Figure 4 (left): Howard Taylor - Study for Blue Sky Figure *1984*
Figure 5 (middle): Howard Taylor - Veiled Figure *1988.*
Figure 6 (right): Howard Taylor - Two Eras *1985.*

These studies by Howard Taylor, in which he was exploring different kinds of gradation and contrast, made clear to me the importance of contrast and the relationships between colour and other aspects of appearance such as transparency and texture. Other artists have written about contrast and the way that colours interact in a painting. Henri Matisse describes how he constantly monitored appearances as he worked on a painting: ‘… each new stroke diminishes the importance of the preceding ones.’ [9]. And Patrick Heron: ‘… differing colours on a flat surface pull and twist against each other … all sensation of colour is relative …’ [10].

Modes of appearance

It is possible to look at an object and experience a sudden change in its apparent colour. This can happen when you change the way you interpret a particular scene. An example is given in *The Science of Color* which was compiled by members of the Committee on Colorimetry of the Optical Society of America [11]:

An officer directing traffic at a busy intersection was observed to be wearing a pair of light blue pants but then, almost immediately, they changed to dark blue. The explanation was that *a pale blue wisp of exhaust fumes hung in the air between the observer and the officer about 50 yards away, and at first the light blue was associated with, or perceived as belonging to, the pants; but almost immediately the observer realized that it was an exhaust cloud which was light blue, whereupon the officer's pants were perceived to match the dark blue of his coat* (p.148).

This is an example of a change in the mode of appearance. The first to provide a systematic account of different modes of appearance was David Katz [12]. A list of the modes proposed by Katz, and others after him, is given in *The Science of Color* (p.145), but the authors regard some of these as attributes or dimensions of modes rather than distinct modes. They recommend the adoption of just five modes (p.146): Illuminant, illumination, surface, volume and film. These can be recognised in Figures 7 and 8.

Colour is perceived in the *illuminant mode* when something like a street lamp is seen to be a source of light. Colour is perceived in the surface mode where the colour is perceived as belonging to a surface. Perception of the colour that belongs to a surface usually requires that the surface is perceived to be lit by 'normal' light. In Figure 7 we can see that the building in the right foreground has grey walls and that the orange appearance of one wall is not the result of that wall being painted with orange paint but is caused by the light from the street lamp. This is an example of the *illumination mode*. The colour of the wine in Figure 8 is perceived in the volume mode. The mode of appearance for the soup is less clear. The soup may be perceived as volume in that it can be assumed that the soup does not change colour below the surface. But the soup is opaque. We cannot see through the soup to the bottom of the bowl in the way that we can see into the wine. All we can be sure of is the colour of the surface. The sky in Figure 7 is not perceived to be the source of light, nor is it perceived to have any kind of surface. And although we can appreciate that we are looking through air we do not perceive the air as having any colour of its own; we do not think that we are looking through a volume of blueness. The blue of the sky is not perceived in the illuminant, surface or volume modes. It is an example of *film colour*. This is colour in its purest form – not part of anything, just colour. Furthermore, the other modes can all be reduced to film mode if you look at things through a small aperture that has the effect of removing the context. This can be simulated by selecting a small area from a photograph and presenting it in isolation. The colour squares beside the photographs in Figures 7 and 8 are each enlarged details from the photographs.

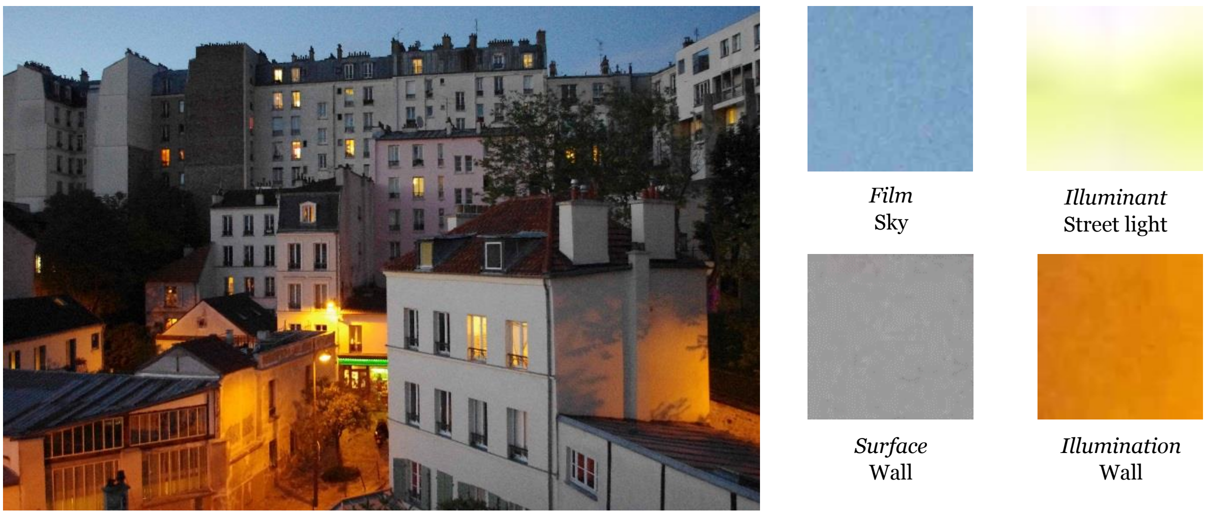


Figure 7: View from a window where the colours of the sky, street lamp, wall lit by natural light and wall lit by artificial light are examples of the film, illuminant, surface and illumination modes of appearance respectively.

Figure 8: View of objects on a lunch table where the wine is an example of the volume mode while the soup may be perceived as volume and/or surface.

Although the volume mode is usually associated with transparent liquids it is possible to think of some opaque materials as being examples of volume colour. That is true of the soup in Figure 8 but it could also be considered true of some objects or substances that are solid. This notion of solid volume colour came up in a conversation with my colleague Colin Latchem. We were having coffee and discussing appearances in a place where we could see one wall that had clearly been painted while another was unpainted brick (Figure 9). Latchem said he responded in a different way to the two surfaces and that he perceived the unpainted bricks as being 'the same colour all the way through'.

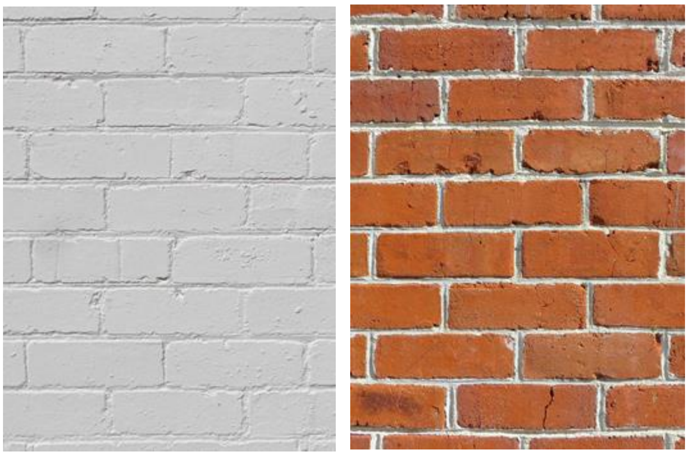


Figure 9: Painted bricks (surface mode) on the left and unpainted bricks (solid volume mode) on the right.

The examples of the soup and the unpainted bricks show that it may not always be easy to make clear-cut distinctions with modes of appearance. Water can be even more ambiguous. My grandson, Mason, made a nice observation when we were looking together into shallow water in an area of wetlands. He pointed out how we could see three different pictures depending on how we chose to direct our attention (Figure 10). We could look through the water to focus on the mud, stones and twigs on the bottom. We could focus on the scum and debris on the surface. Or we could focus on the reflections of trees and sky above.

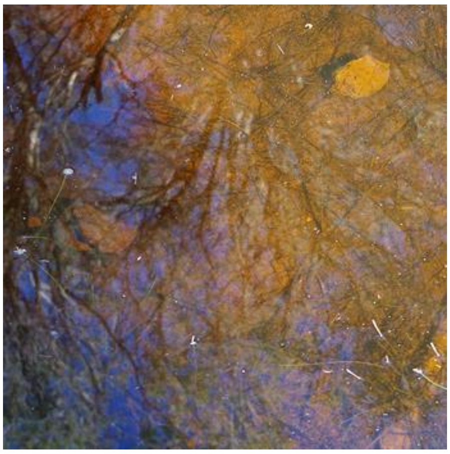


Figure 10: Three possible 'pictures' from shallow water: the bottom, the surface and reflections.

With less confined bodies of water, such as the sea, we do see distinct colours, but such colours do not seem to 'belong' to the sea in the way that the grey of the wall in figure 7 seems to belong to the wall. In his book *Venice: Pure City*, Peter Ackroyd discusses the distinctive colours of the city and especially the colours of the water [13]:

What is the colour of the water in the canals and in the lagoon? They have variously been described as jade green, lilac, pale blue, brown, smoky pink, lavender, violet, heliotrope, dove grey. After a storm the colour changes as the water becomes aerated. On a hot afternoon the waters may seem orange. The colours of the sky, and the colours of the city, are refracted in little ovals of ochre and blue. It is all colours and no colour. It reflects, and does not own, colour. It becomes what it beholds.

Figure 11: Photographs taken during a holiday in Venice.

The photographs in Figure 11 were taken during a holiday in 2010. In the first photograph the water seems to be acting like a rather dark mirror, reflecting the colours of the buildings and sky. In the second photograph, while the orange is clearly a reflection of the building, there is a difference in hue between the greenish grey of the water and pale bluish grey of the sky which could be due to something in the water itself. The possibility of the water having a colour of its own is most apparent in the third photograph. Here there are no reflections of the building or the sky. The water is opaque and the colour is quite different from that of either building or sky. When perceiving the water here we can switch between the surface and the volume modes as we did with the soup in Figure 8.

Making visible

A major exhibition of Howard Taylor's work was held in 2003, two years after Taylor's death. The title of the exhibition and accompanying catalogue was *Phenomena* [8]. In their Forward to the catalogue the directors of the Art Gallery of Western Australia and the Sydney Museum of Contemporary Art, Alan R Dodge and Elizabeth Ann MacGregor, summarise their assessment of Taylor's achievement: 'Taylor captured the changing light and colour of the Australian bush with unparalleled conceptual subtlety and artistic precision. His work demonstrates for us all that the more one looks the more enlightening experience becomes.'.

Many of Taylor's paintings are distillations of phenomena observed in the landscape rather than pictorial representations of fields and trees. *Study for Blue Sky Figure* (Figure 4) represents a phenomenon observed in the karri forest in the south west of Australia where Taylor lived. When you are in the forest and you look up, the sky can be glimpsed through 'windows' framed by the grey of the tree trunks. The blue of the sky induces its complementary in a pink tinge in the grey window frame. Taylor used the simple format of concentric rectangles to represent this phenomenon. Taylor's nearest neighbours were farmers who had little knowledge of the traditions of landscape painting but he told me how one of his friends had looked at this study and had a sudden moment of recognition: 'I've seen that!'.

Taylor was much influenced by the ideas of Paul Klee and Taylor's work can be taken as an illustration of Klee's dictum from his *Creative Confessions* of 1920 that 'Art does not reproduce the visible, it makes visible' [14]. This quality of Taylor's work, that was identified in the catalogue for *Phenomena*, was also recognised by two commentators when reviewing an earlier exhibition in 1993. David Bromfield describes Taylor's drawings as 'instructions for seeing' [15] and Ted Snell describes the same works in a similar way: 'For the viewer the paintings and drawings in this current exhibition are a kind of instruction manual for looking at the natural environment.' [16].

There are many ways in which artists 'make visible'. On a tour of Australia in 1977 Bridget Riley had an enforced stop-over in Perth because of an airline strike. She was able to visit Taylor in his studio and her enthusiasm for his work led to his being offered an exhibition in Sydney. For Riley, also, painting was a way to make visible [17].

> *I discovered that I was painting in order to 'make visible'. On one hand I had to make something which had this essential quality of precipitating itself as 'surprise' and, simultaneously, there was no way of knowing with what one was dealing until it existed; so that in order to see one had to paint and through that activity found what could be seen.*

Visual phenomena and physics

Just as music notation is ultimately about the phenomena of sound rather than the physics or mechanics of sound so any notation system for the visual arts should be about the phenomena rather than the physics of appearance. The physicist W.D. Wright played a leading role in the development of techniques for measuring colour yet, at the Forsius Symposium on Colour Order Systems in 1983, he stressed that 'the overriding value of a colour order system is that it deals with colour as we see it and not as we measure it.' [18]. During a discussion at the same meeting Sven Hesselgren emphasised the importance of making a distinction between sensation/perception and physics [19]:

> *It is absolutely necessary to understand that you cannot describe anything concerning any kind of sensation by means of physics. … You do so – yes, you call the radiation from radiation sources light. It is not light. Light is the sensation that appears in your mental inside. It is awakened by means of the radiant energy, but that is something quite different from the sensational perception. The same stands for color, of course.*

Hesselgren's own colour atlas was a step on the way to the Natural Colour System (NCS). The NCS is based on Ewald Hering's notion of six Elementary Colours (Urfarben) as perceptual reference points in relation to which any colour's appearance can be judged [20]. I value my copy of the NCS atlas but must keep reminding myself that the atlas is only an illustration of the system and not the system itself. I have even suggested that production of a physical atlas might be counter to the spirit of the NCS. The fact that the NCS is based strictly on how colours appear was impressed upon me by Grete Smedal in 1981 when I first met her at the Bergen Kunsthåndverksskole in Norway where she was teaching. I was struck by the fact that Smedal and her students had been working successfully with the NCS for a number of years before 1979 when the NCS atlas was first published.

More than colour

The NCS is limited to normal surface colours. This excludes the other modes of appearance, illuminant, illumination, volume and film. The NCS Gloss Scale has samples in seven gloss levels from full matte to high gloss, but the system excludes fluorescent colours and surfaces that are metallic or textured. While considerable progress has been made in techniques for measuring the physical properties of these other aspects of appearance, there is little which deals with the phenomenal aspects.

As I have said earlier, Ruskin claimed that our ability to perceive form is built on our experience of seeing 'patches of different colours variously shaded.' To take a simple example, a circular patch of red, shading from light to dark, would be perceived to be a red ball. However, there is more information to be gained from the character of the shading: how great a contrast there is in the shading between lightest and darkest; whether the shading is interrupted by a patch of white; whether the shading is smooth or broken in any way. From this additional information we perceive the balls to be matte, glossy, metallic, translucent or textured. And we can identify one ball as a snooker ball and another as a Christmas tree ornament. These distinctions are illustrated in Figure 12.

While these features might also be identified by measurement, it is their distinctive appearance that is of concern here. The balls are closely similar in colour but our response will vary as the balls vary in surface quality and texture. Some kind of framework to show relationships between all these aspects of appearance could raise people's awareness and their appreciation of what they see around them. It could also extend the range of possibilities for art and design.

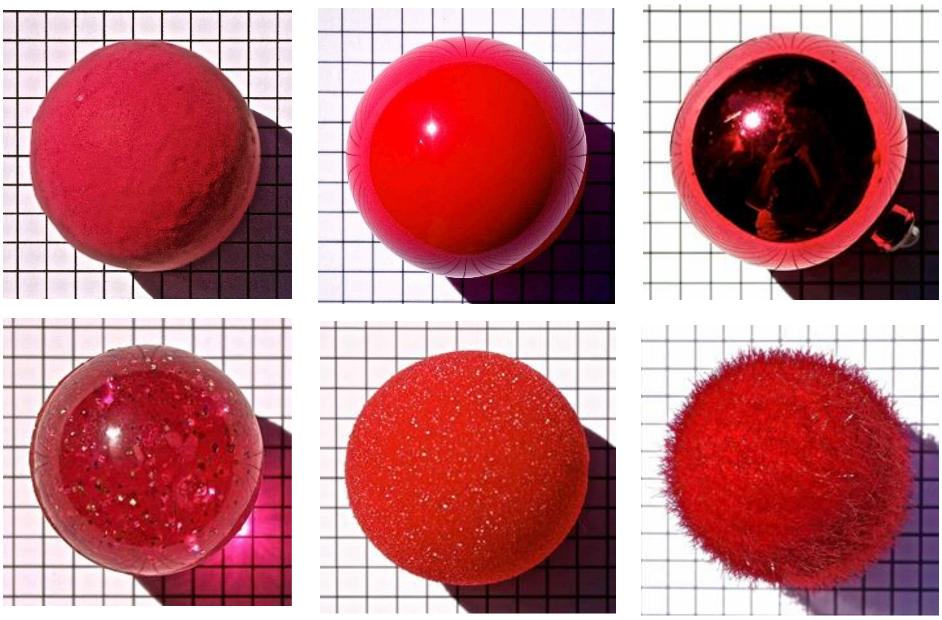


Figure 12: Red balls that are perceived to be matte, glossy, metallic, translucent, speckled, textured.

A more complete picture

The *Planets-Colour-System* was devised by Michel Albert-Vanel for representing colour combinations rather than single colours. Albert-Vanel describes the system [21-22] and also how he used the system to extract 42-colour palettes from paintings by the Impressionists and their contemporaries [23]. The system deserves to be better known. It offers a new field of possibilities, but Albert-Vanel still recognises that more is needed [21 p.287].

> *The most complete color system would have to incorporate not only scales showing hue, value, and saturation, and contrasts of hue, value, and saturation, but also scales showing the oppositions of pigment and light, opacity and transparency, and matte and gloss surfaces. It would be impossible to represent all these dimensions of color within one diagram, but the color theorist could take any two or three dimensions to show as a two-dimensional diagram on paper or as a three-dimensional solid.*

The model presented in a later section is intended to serve as a framework for linking the different dimensions of appearance referred to by Albert-Vanel. The model shows relationships between sources of light and objects that appear variously transparent, translucent, matte, glossy, metallic and textured as well as appearing different in colour. However, whatever its merits, no model can encompass the full experience of seeing the world in space and time. This is acknowledged by the authors of *The Science of Colour* when they refer to 'the infinite variety of textures and settings with which colours are perceived in common visual experience.' [11 p.145].

The complexity of common visual experience is the concern of Juliet Albany. In a session at the AIC Congress in 2009 she presented a series of observations that were the fruits of her efforts to grasp the totality of what she sees around her, especially the influence of the changing natural light on local appearances in and around the place where she lives, her namesake city of Albany on the south coast of Western Australia [24]. One year later, members of the Colour Society of Australia joined her in Albany for a series of workshops to explore her ideas. A major aim of the workshops was to find ways of describing visual phenomena that could help members of a community to become more sensitive to the particular visual qualities of their surroundings.

Juliet Albany took us on one of her favourite walks to point out the influence of light on local appearances. She overturned my notion that the colours of nature are best seen in bright sunlight. In bright sunlight the contrast between light and dark can be more salient than the contrast between different hues. On this walk I learned to appreciate the subtle and delicate colour contrasts in overcast conditions (Figure 13). Three days later the sun came out for another walk (Figure 14).

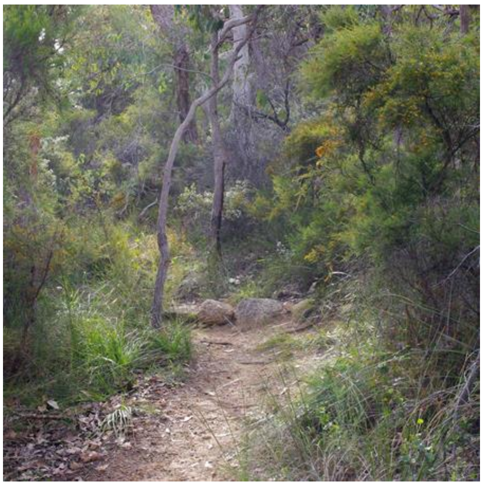


Figure 13 (left): Walk track on Mt Adelaide, Albany, Western Australia, in overcast conditions.
Figure 14 (right): Walk track on Point Possession, Albany, Western Australia, in bright sunlight.

Figure 15: Still life display for studying different modes and different aspects of appearance. Photographs by Anthony Marrion reproduced with permission.

Like Howard Taylor, Juliet Albany sees little to be gained from working with colour chips. For the workshops we decided to look at three-dimensional objects.

A collection of objects, that exemplified different modes of appearance and that exhibited a wide variety of appearance characteristics, was assembled as a 'still life' (Figure 15). There were two illuminants in the display: the tail light of a motor-car and a candle flame. The wine and the milk in glasses were examples of the volume mode. In the surface mode, objects were smooth, textured, glossy, lustrous, transparent, translucent and opaque. The task was to write down words for describing each object. Many found this difficult because they could not find words to describe some of the particular qualities they saw. Close observation and detailed description were common. We also explored the ways in which different aspects of appearance can be related.

Constructing scales of appearance

A good way for developing students' sensitivity to appearances is to give them a number of similar objects and ask them to arrange the objects 'in order'. This requires that they look closely at the objects to see what aspects of appearance there are that could be used as a basis for the order. The objects might be arranged by size, by shape, by colour, by texture.

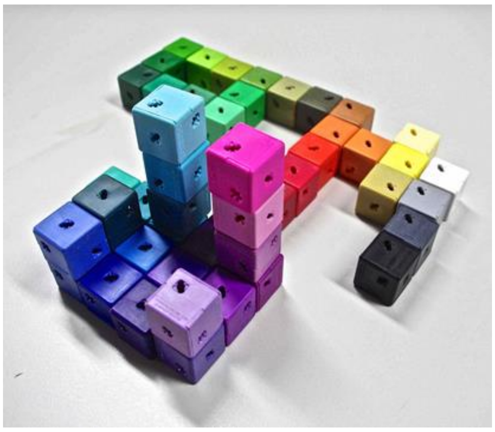



Figure 16 (left): Students' solution to the task of arranging coloured cubes 'in order'.
Figure 17 (right): Students' solution to the task of arranging buttons 'in order'.

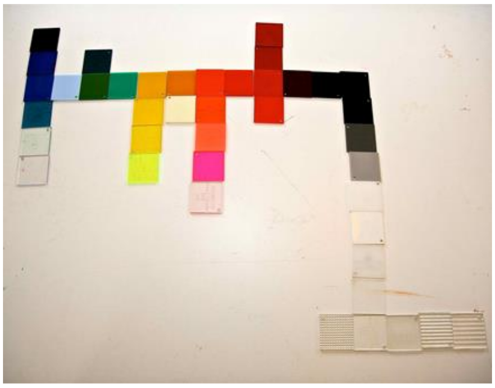
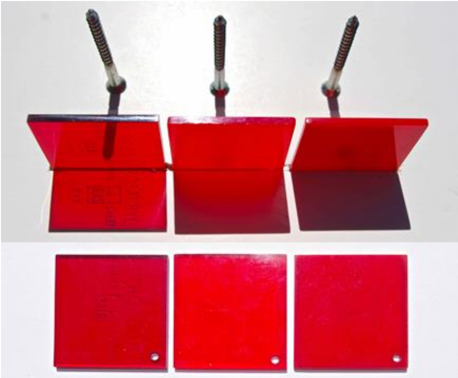



Figure 18 (left): Plastic samples 'arranged in order'.
Figure 19 (right): Three of the samples showing how context is needed for distinguishing transparency, translucency and opacity.

Some of the students who worked with the coloured cubes came to the realisation that the arrangement would have to be three-dimensional (Figure 16). The buttons presented new problems. Not only did the buttons vary in colour, but some were matte, some glossy, some metallic, some transparent (Figure 17). We did this same exercise in Albany as a follow-up to the task of describing the objects in Figure 15. People were divided into three groups, each group working with a different set of objects. Figure 18 shows how one group ordered a set of plastic samples, some of which were transparent, some translucent and some opaque.

Here we could see the importance of making a clear distinction between physical properties and visual phenomena. Three of those plastic samples are shown in Figure 19. The shadow cast by the screw can only be seen clearly through the transparent sample on the left. The middle sample is translucent. It allows light to pass through – hence the red shadow. The sample on the right is almost completely opaque. Very little light can pass through; the shadow is essentially black. But when the samples are laid flat on the table it is no longer possible to be sure which is physically transparent, which translucent and which opaque. We need the context and the shadows. Context can also lead to perceptions of transparency and translucency even when an object is physically opaque. This can be seen in Howard Taylor's painting *Veiled Figure* (Figure 5).

The other two groups worked with objects that exhibited other aspects of appearance: texture, gloss and metallic lustre (Figures 20 and 21).

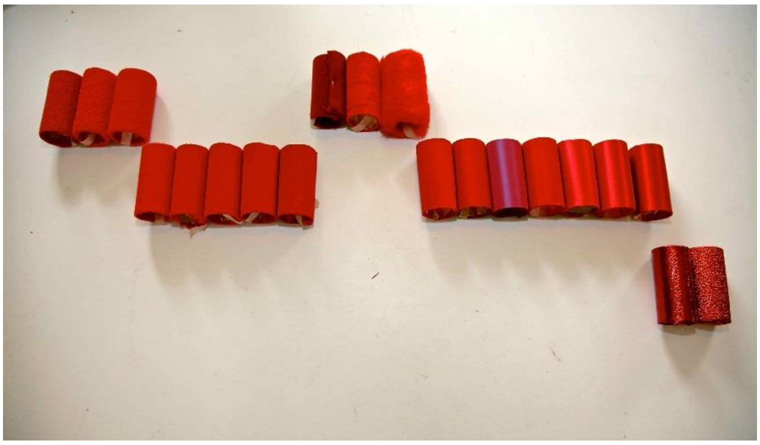


Figure 20 (left): Plastic samples taped round cylinders.
Figure 21 (right): Fabric samples taped round cylinders.

Texture was revealed by the contrast between the small elements that constituted the texture. The cylindrical shape of the objects meant that, for each object, there was also the contrast between high-lights and shadows that is especially characteristic of gloss and metallic lustre. The difference between gloss and metallic lustre can be seen in the colours of the highlights. Highlights on a glossy surface are the colour of the light source; on a lustrous surface highlights are of the same hue as that which is perceived as 'belonging' to the surface. This is pointed out by W.D. Wright when he explains how we identify an object as being metal [25]:

How do we know it is metal? Mainly by its specular reflection – the high-lights and the low-lights reflecting the sources and objects in its neighbourhood; and if it happens to be a coloured metal like copper or gold, then the high-lights will be coloured by the characteristic hue of the metal, unlike the colourless high-lights in most other glossy surfaces.

In each of the three sets it was difficult to arrange the objects in a single linear sequence. In the set shown in Figure 20 the basic division between the inner and outer rings is clear enough, but the outer ring is further subdivided: cylinders were ordered by gloss, by metallic lustre and by patterned metallic lustre. But we saw how two of these separate groups could be linked (Figure 22). A matte white cylinder could connect to cylinders of increasing gloss in one direction and increasing metallic lustre in another.

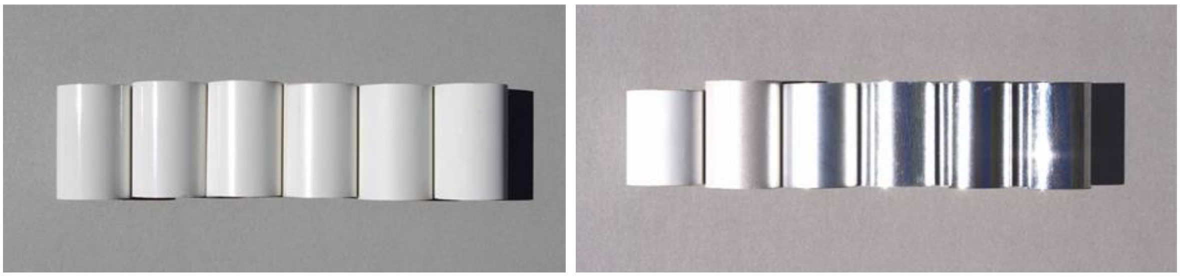


Figure 22: Two groups of cylinders from figure 20 showing scales of increasing gloss in one direction (left) and increasing metallic lustre in the other (right). The scales have matte white as a common starting point.

The group working with the fabric samples kept rearranging them before finally settling on the arrangement shown in Figure 21. The two sets of three samples above include velvet, towelling, a fleecy material and fabrics with distinctive patterns in the weave. The set of two below are lamé fabrics with metallic threads in the weave. In the middle, the set of five on the left varies in the coarseness of the weave while the set of seven on the right varies in the degree of sheen. For each of these two sets the starting point was a finely woven fabric with no sheen. Like the cylinders in Figure 20, two separate scales could be constructed from the same starting point. For the fabrics there were scales of increasing coarseness of weave in one direction and increasing sheen in the other.

Expanding the vocabulary

When asked what he was going to teach, Josef Albers, newly arrived at Black Mountain College, is reported to have said that he aimed: 'To make open the eyes.' [26]. His students were to learn, first, how to see. The ability to see, as Albers demanded, can be nurtured with the help of words. When Ammon Shea read the *Oxford English Dictionary* he found a link between the acquisition of new words and a richer experience: '… if I know there is a word for something … I will stop and pay more attention to it.' [27]. So I believe that new words and new diagrams can serve as tools that help us to see and to think about what we see.

The workshop exercise where we tried to find suitable words to describe the appearance of the objects illustrated in Figure 15 revealed the shortcomings of the English language. We could see particular qualities of appearance but, without words to describe those qualities, we had difficulty recording and communicating what we saw. This kind of problem was recognised by Ezio Manzini. The aim of his book *The Material of Invention* [28] was 'to supply cognitive tools and cultural reference that may help to make the new fields of the possible more easily thinkable for the designer. … every new word acquired is a glimpse of the possible.' This problem was also recognised by César Janello when he was developing his Theory of Design.

Janello's pioneering work is described briefly by José Luis Caivano [29]. Janello had been struck by the way that three-dimensional colour order systems organise our perceptions of colour and he developed similar three-dimensional models for characterising form and texture. However, there were aspects of appearance that seemed related and which might be organised into a fourth three-dimensional model, but for which there was no generic term. In the absence of a term that embraced transparency, translucency, opacity and mirror-like reflectivity he coined a term of his own – cesia – derived from his name César. Armed with the term cesia we can stop and pay more attention to phenomena of transparency, translucency, opacity and reflectivity, and the term can help us to glimpse the possible. Better still, we have the model of cesia developed by Caivano which shows how the different dimensions of cesia relate [29- 31]. (Caivano's model is described in more detail in a later section.)

Caivano's model for cesia complements three-dimensional colour order systems and Janello's own models for form and texture. Janello's model for form, or spatial delimitation, is based on simple geometry with planes ranging from the triangle to the circle and volumes ranging from the tetrahedron to the sphere. But for Janello, texture was 'an almost unexplored dominion' which could be modelled to provide more glimpses of the possible [32]:

> *The study of texture as a visual phenomenon tends to modify our manner of functioning in the world, since undoubtedly texture is a significant factor that always intervenes in our perception; and, once treated, should amplify the horizon of the creative imagination.*
>
> *The lack of vocabulary to individualize textures and to define their characteristics demonstrates our conceptual incapacity …*

Janello's three dimensions of texture are size, density and directionality. The size of elements that constitute a texture reach an upper limit when the perception of texture gives way to that of pattern. Maximum density for a texture would be represented by a fine checkerboard and maximum directionality by corrugated cardboard. Janello suggests that his model could be used for developing harmonies of texture much as colour order systems are used for developing harmonies of colour. Caivano makes similar claims for possible harmonies of cesia and he defends the use of such systems from possible attack [29 p.267].

> *Artists and designers may feel that systems of this kind work against spontaneity, freedom, or inspiration. This is a completely erroneous way of thinking. A system like this, the color systems, or similar ones for spatial delimitation or texture, contain, at least in abstract, the complete universe of possibilities.*

The models developed by Janello and Caivano, as well as colour order systems, do help us to appreciate and describe appearances but we have found that there are some surface qualities that defy incorporation in a model. Following the workshop in Albany I set students from Edith Cowan University the task of describing another set of objects (Figure 23).

A piece of hard-wearing carpet and a paving brick were both described as 'rough' and could be located in Janello's model for texture but the carpet was also 'soft' while the brick was 'hard'. A candle, a plastic model of the Panton chair and a rubber glove were all 'smooth' and 'shiny' and could be located in Caivano's model for cesia, but the candle was also 'waxy', the model chair was 'plasticy'[sic] and the glove was 'rubbery'. Words used for describing other objects included 'furry', 'silky', 'grainy', 'dimpled' and 'speckled'. Geologists in the field use a number of words, including 'silky' and 'waxy', to describe what they find as a first step towards identification [33]. Nevertheless, having a framework for describing appearances can take us a long way and help make up for the shortcomings of our vocabulary.

Figure 23: Some of the objects which students were asked to describe.

There remains one important element missing from Janello's Theory of Design, one that was mentioned by Albert-Vanel, and that is light and its influence on appearances.

Light and the effects of lighting

Light sources can be perceived directly; they also have a strong influence on how objects appear. Light sources can be characterised as having three dimensions: they vary in intensity, in colour, and in 'quality'. The quality, or coherence, of a light source refers to the hardness or softness of the light [34]. Hard light is sharply focused; soft light is diffused. An object lit by hard light will cast strong, well defined shadows and any irregularities of the surface will be clearly revealed. Textures are best revealed under hard light. Soft, or diffused light does not reveal surface irregularities to the same extent and the shadows cast by objects are indistinct or absent. Sunlight on a clear day is an example of hard light while cloud cover on an overcast day has the effect of softening the light. The effects of hard and soft light can be compared in Figures 13 and 14.

The three dimensions can also be recognised in the light sources themselves which are perceived in the illuminant mode. Figure 24a is a photograph taken of the Sun from the coast of Western Australia. It was early in the morning with no clouds in the sky. The sun is perceived as a source of hard light, high in intensity and having no bias to any particular part of the spectrum. This is in contrast to the sun in Figure 24b which was photographed in the evening through the haze above Beijing. Not only is this light source perceived to be softer, but it is also less intense and has a bias towards the long wave end of the spectrum. Figure 24c is a photograph taken in Perth of the full moon. Although we know that the moon simply reflects light from the sun, it certainly appears to be itself a source of light – hard, with no colour bias, but much less intense than the sun. It is only when you look through a telescope (Figure 24d) that you perceive the Moon as an object. Seen with the naked eye the Moon is perceived in the illuminant mode. When looking through a telescope we experience a switch from illuminant to surface mode.

(a) (b) (c) (d)

Figure 24: (a) The Sun taken on a clear day from the south coast of Western Australia; (b) The Sun taken in the evening through the haze above Beijing; (c) The Moon taken from near Lake Jualbup, Perth, is perceived in the illuminant mode; (d) The Moon taken through a telephoto lens. The Moon is now perceived in the surface mode.

An understanding of different light sources, and the influence they have on appearances, is of central concern for people who design for television, theatre and film. It should also be of concern to artists who work in sculpture, installation and performance, and to designers of interiors. The effect of different lighting in interior spaces is discussed by Monica Billger [35] and Maud Hårleman [36].

A model of appearances

The observation from our workshop in Albany, that one kind of appearance could connect with a different kind of appearance, suggested the possibility of a model for appearances: a three-dimensional network of appearance sequences, linked through what can be called 'primary sensation nodes'. The matte white cylinder would be at one such node connecting scales of gloss and scales of metallic lustre. The finely woven fabric would be at the same node but would connect scales of gloss, or sheen, with scales of increasingly coarse texture.

The model has at its core the model proposed by Caivano for cesia. When I first encountered Caivano's model I recognised its superiority over a model I had proposed in 1989 which had been an attempt to link colours that are opaque to colours that are transparent [37]. I had been struck by the fact that there are two colours that can never be transparent. While you might be able to see clearly through a sheet of red glass you could never see through glass that is black or white. The light would be absorbed in the black glass and scattered by the white. Caivano's model for cesia is roughly in the form of an inverted square pyramid with five primary sensations at the vertices. This can be represented in two dimensions (Figure 25).

Diffuse transmission leads to the perception of translucency as when you look at frosted glass that is lit from behind. Although the glass transmits light, the light is scattered and you can not see objects clearly on the other side of the glass in the way that you can when you look through clear glass. With clear glass the transmission is regular and the perception is of transparency. Among the plastic samples shown in Figure 18 there are some that are transparent, some translucent and some opaque. One of each is shown in Figure 19. It is a curious feature of English that we would describe all three of these samples as 'red', but that if we had an equivalent set of three samples and would describe the opaque and translucent samples as 'white' we would not call the transparent one white. We can look at the world through rose-coloured glasses but not through white ones. We have to use a word like 'clear' which implies that the sample is not only physically transparent but that it transmits nearly all the light evenly across the spectrum.

ISSN 2227-1309

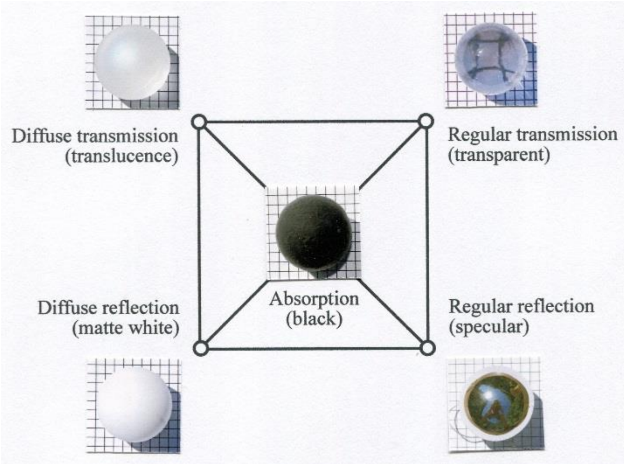


Figure 25: Caivano's model for cesia presented in two dimensions.

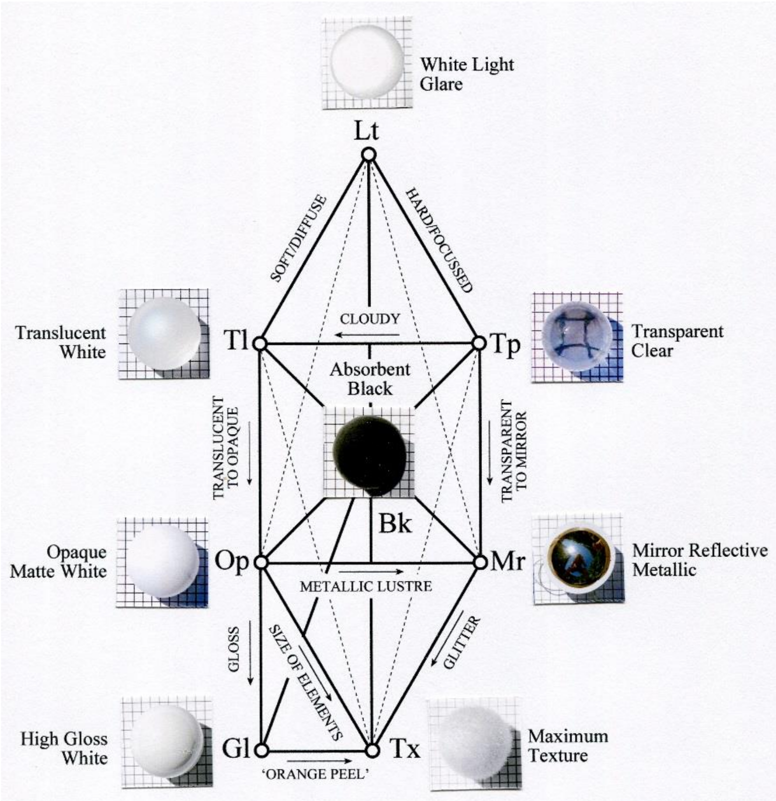
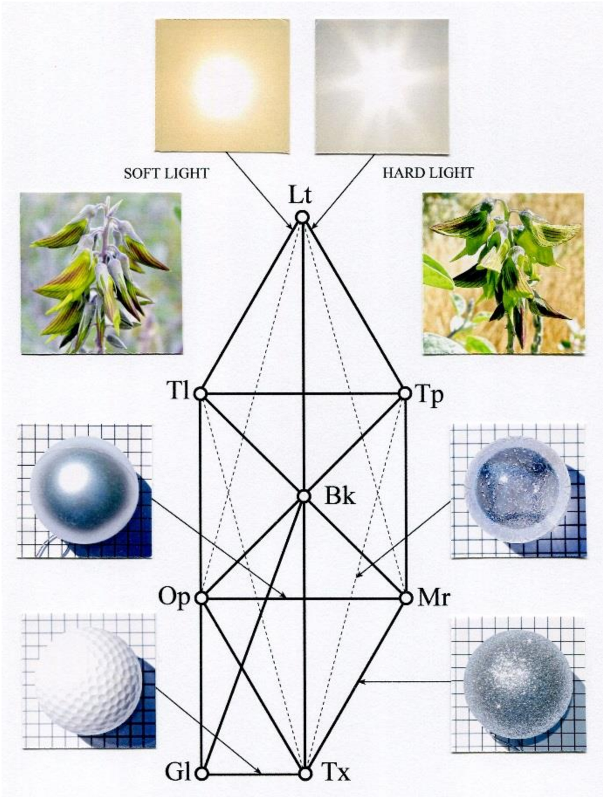


Figure 26: Model of appearance phenomena showing relationships between primary sensation nodes.

Caivano's model has matte white and mirror-like reflection as primary sensations at two of the vertices, so the line connecting them would accommodate the sequence shown at the right of Figure 22. To accommodate scales of gloss and texture I have added two more primary sensation nodes, one for high gloss and the other for maximum texture where the size of textural elements falls just short of being perceived as part of a pattern. I have added a third primary sensation node to allow for the inclusion of light. Light intensity can be measured but when it reaches a certain point we experience glare as with the Sun in Figure 24b. Glare is the end point of scales for light which would have a place for everything perceived in the illuminant mode. This would include less intense light sources, such as traffic lights, as well as surfaces that are physically fluorescent and those that are 'fluorent'. A surface may not be physically fluorescent or a source of light but, in certain contexts of illumination, it may appear so. The term 'fluorence' was coined by Ralph Evans for this phenomenon [38]. The Moon, as it appears in Figure 25, is a case in point. The conditions required for the experience of fluorence are described by Osvaldo Da Pos [39]. The new model, with high gloss, maximum texture and glare added to Caivano's model, is shown in Figure 26.



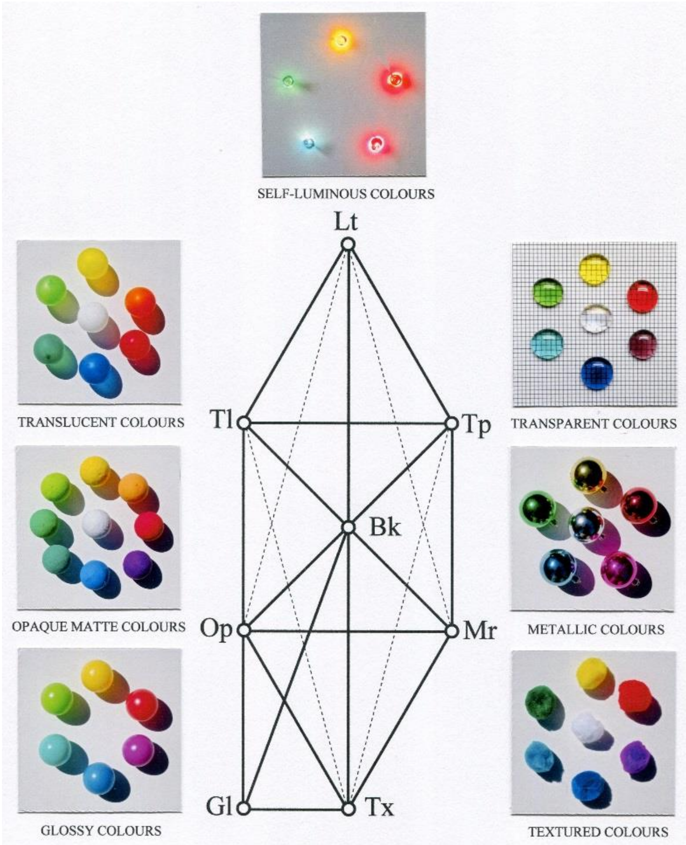


Figure 27 (left): Objects connected to positions on the scales of appearance represented in the model.
Figure 28 (right): Hue circles in different aspects of appearance related to the model.

Objects can now be located on the scales of appearance represented in the model. It is also possible to locate sources of hard and soft light according to their apparent intensity. The effect of hard and soft light on the appearance of objects can also be related to the model. Examples are shown in Figure 27.

The lines that connect to black can serve as the achromatic axes of order systems for colours that are self-luminous, translucent, transparent, matte/opaque, mirror/metallic, glossy or textured. In this way colours and the various aspects of appearance can be connected. Hue circles for such different colour order systems are shown in relation to the model in Figure 28.

The triangular diagrams in Figure 29 represent typical hue planes for order systems of translucent and metallic colours. These are modelled on the NCS colour triangle; a hue plane for opaque colours would be that of the NCS itself.

The hue circle and nuance triangle used as symbols to represent colours in the NCS can now be combined with the relevant part of the model of appearance to provide a more complete description of an object's appearance. Three lines to represent the size (Sz), density (Ds) and directionality (Dr) of a texture from Janello's model can also be included where desired. Notations for the appearance of a transparent and a textured button are shown in Figures 30 and 31.

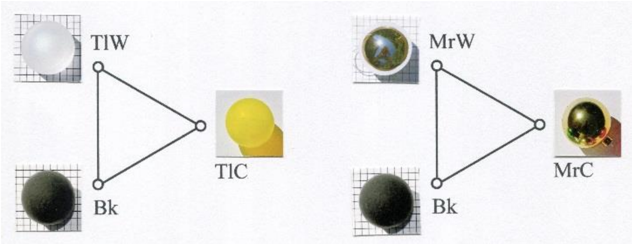


Figure 29: Hue planes for order systems of translucent and metallic colours.

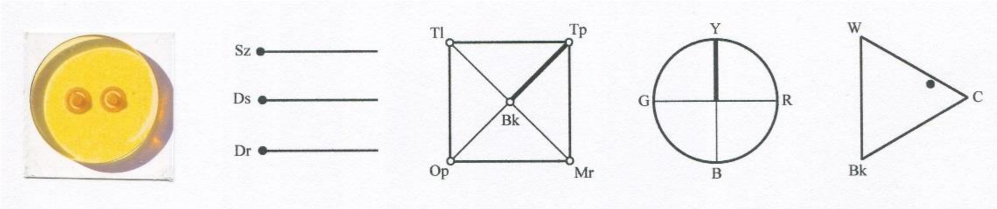


Figure 30: Symbols to indicate the hue, nuance and cesia of a transparent yellow button.

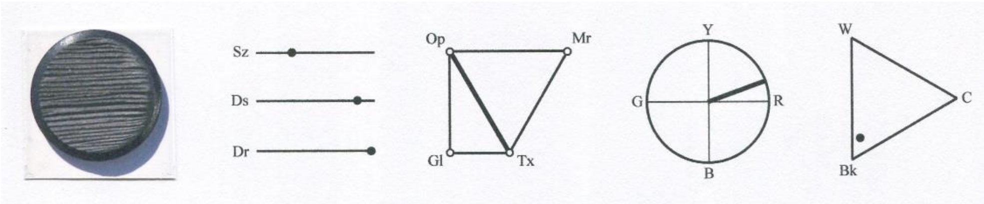


Figure 31: Symbols to indicate hue, nuance and texture of a textured black/brown button.

The combination of symbols in Figures 30 and 31 indicate the buttons' hues, nuances, cesias and textures. I once suggested that such combinations of appearance characteristics might be combined under the term 'tincture' [1-2]. Tincture has more than one meaning in English but its meaning in heraldry is what attracted me: 'an inclusive term for the metals, colours and furs used in coats of arms.' [40]. A coat of arms that featured gold discs on a red band above a pattern to indicate ermine would include cesia (gold), colour (red) and texture (ermine). While each of these are treated as separate tinctures in heraldry I was proposing that the word might be used for these aspects of appearance taken together. So the tincture of one button would include its transparency as well as its colour and that of the other button would include its texture. It is unlikely that the language will embrace the term with this particular meaning but I would like to be able to say that I admired the tincture of someone's dress and know that I would be understood to mean the texture and any property of glossiness or translucency as well as the colour of the material from which the dress was made.

Total appearance

A word that would embrace all these aspects of appearance would be particularly useful in the food industry. John Hutchings explains how 'the word "color" has superseded "appearance" as the description of the total visual perception of foods' [41]. He explains how storage and processing can bring about changes in appearance which are treated as 'a change in "color" even though, as is often the case in fish processing ... the change could be entirely due to translucency effects.' Hutchings has developed a theory of total appearance that goes beyond the model presented here [42]:

The term total appearance is used to describe the impact and expectations generated by the arrangement of materials in view, for example, the design of an item of packaging or the placing of furniture and distribution of illumination in an interior.

Hutchings goes on to say that the term should also include what we smell, taste or feel. An essential feature of the concept is that it includes the expectations that people have and the way they respond. Hutchings makes use of the Color Image Scale devised by Shigenobu Kobayashi [43-44]. Kobayashi relates single colours, colour combinations, textures, patterns, objects and environments to what he calls 'images'. The image words are organised in a 'semantic space'. So the location in that space of an image word like 'pretty' is also the location for materials that communicate that image: colours that are light or pale such as pink and pale green, fabrics that are finely woven, translucent and trimmed with lace, and delicate floral patterns. If a 'pretty' image is inappropriate, and a 'dynamic' image is preferred, the designer can see what changes would be needed to communicate the new image and would choose more vivid colours, fabrics that were less translucent and were more glossy, and patterns with larger elements and stronger contrasts.

There are four levels in the total appearance model: Level A is the whole space; level B is the design components – the treatment of walls, ceiling and floors, the arrangement of furniture, the decoration and lighting: level C is the component elements – seats, tables, fireplace, light fittings; level D is the materials – wood, metal, textiles, plastics. The model described in this paper deals only with appearances at level D, but I hope that greater clarity at this level will help designers working at all levels of the Hutchings model.

Filling the gaps

Colour order systems have largely overcome the problems associated with our limited vocabulary of colour names. I hope this model for appearances, which connects with colour order systems, will help fill the gaps in our language for describing other aspects of appearance as well as illuminating some of the questions posed by Ludwig Wittgenstein [45]:

Why is it that something can be transparent green but not transparent white?

We speak of the 'colour of gold' and do not mean yellow. 'Gold coloured' is the property of a surface that shines or glitters.

Equivalent sets of objects are shown in Figure 32.

(a) (b) (c)

Figure 32: (a) 'Green' objects; (b) 'White' objects; (c) 'Yellow' objects.

In Figure 32a all the objects and the background are green and they can be light, dark, dull or vivid, transparent or opaque, matte, glossy or metallic. In Figure 32b only the translucent, opaque, matte and glossy objects can be white as long as they are also light. Dark white would be grey. The transparent glass is 'clear' and the metallic candlestick is 'silver'. In Figure 32c the transparent, matte and glossy objects are yellow, but the dark object is 'brown' and the metallic object 'gold'. These anomalies disappear in the model where the relationships between green and dark green, opaque green and transparent green, matte green, glossy green and metallic green can be seen to be the same as those between white and dark white (grey), opaque white and transparent white (clear), Matte white, glossy white and metallic white (silver). And the same relationships can be seen between yellow and dark yellow (brown), opaque yellow and transparent yellow, matte yellow, glossy yellow and metallic yellow (gold).

When words like 'clear', 'silver' and 'gold' are linked to points in the model we can see how we lack equivalent words for other points. The model shows what possible words we are missing as well as compensating for their lack. The gaps in the vocabulary are a bit like the gaps left by Dmitri Mendeleev in his periodic table of elements. The model has points for words if ever they become current, just as the periodic table had places for elements that had yet to be discovered.

Exploiting the possible

When Howard Taylor painted *Veiled Figure* (Figure 5) he was exploring the possibilities of contrasting cesias and the perception of transparency. Contrast of texture is a feature of *Two Eras* (Figure 6). The two eras of the title are the era of the Impressionists and that of the Renaissance. It is a small study, in oil on paper, so the texture of the paper is visible, but Taylor painted the bottom half in the manner of academic painters before the Impressionists with smooth gradations of tone and no visible brush strokes. Visible brush strokes were characteristic of paintings by the Impressionists and it is their technique that Taylor has used for the top half of the painting.

Contrast of cesia and contrast of texture as well as contrast of colour can be exploited by designers as well as artists. The keynote speaker at the 2014 national conference of the Colour Society of Australia was landscape designer Julian Croudace. Among other examples of his work he showed us his solution to a near impossible problem. Bay View Terrace is the main shopping street in Claremont, a fashionable suburb of Perth. Recently a large new shopping centre has been built at right angles to Bay View Terrace. This has attracted many customers who would once have patronised the older shops.

A solution could have been to close Bay View Terrace to traffic thereby creating a pedestrian mall as an extension to the new shopping centre. But vehicle access was still needed. The solution proposed by Croudace is a pedestrian mall where vehicles are allowed but where their movement is restricted. There is no longer a change in level to separate pedestrians from vehicles. A key feature is the treatment of the surface. This is very different from the surface of other roads and gives a clear indication to motorists that they are entering an area which they must share with pedestrians and so must drive slowly and exercise caution (Figure 33). Croudace explained how he extended his notion of 'colour' to include different surface qualities and textures. He was using the word to describe other aspects of appearance much as people in the food industry describe a change in translucency as a change in 'colour'. Some of the paving slabs are very slightly glossy and the variation in texture could be plotted in Janello's model according to the size of textural elements, their density and directionality (Figure 34).

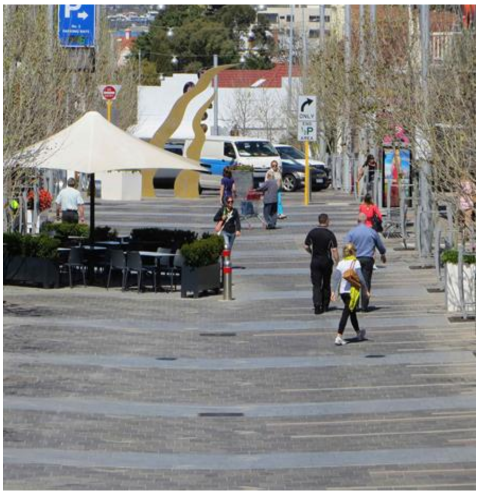


Figure 33 (left): Vien down Bay View Terrance which vehicles share with pedestrians.
Figure 34 (right): Details of paving in Bay View Terrance showing variations in texture.

With a computer it is possible to simulate a range of colours, textures and cesias and the effect of light on objects and spaces. All the examples in this article, except for those in Figure 15, are photographs I have taken in different places, and of objects I have collected or made. I am grateful to photographer Anthony Marrion for permission to use the photographs in Figure 15. A follow-up project would be for someone with better computer skills than mine to use a computer program to generate images of a range of objects to illustrate the scales of appearance suggested by the model in Figure 26. This could constitute a kind of library of the possible.

Opening the eyes

The best way to learn how to see is to draw. In order to draw something you need to look closely and take careful note of the shapes, tones, colours and textures and the way these are revealed in the light. Howard Taylor filled many sketchbooks with exquisite drawings of the natural world paying particular attention to effects of light.

You can also learn how to see by taking photographs. With a digital camera, and a simple editing program on your computer, you can crop, straighten, enlarge and adjust the colours and clarity of your images. Small details are enlarged on the screen. Through this process you can come to see features that you may have missed when you first took the photograph. As with drawing, you can note the shapes, tones, colours, textures and, especially, the influence of light on appearances.

It can be particularly revealing to take photographs of the same scene at different times of day and in different weather conditions. Uluru (Ayers rock) is a large sandstone monolith near the geographical centre of Australia that is famous for the way it appears to change colour. While the rock remains physically unchanged it does, indeed, appear to change colour. This phenomenon is most dramatic at sunrise and sunset when the high proportion of long-wave radiation from the sun is reflected strongly by the surface of the rock. The geological composition of the rock is complex and, if it has a 'true' colour, it is grey. It is the oxidation of iron-bearing minerals in the outer layer of rock that has resulted in its reddish colour which then appears more intense at the beginning and end of the day. A photograph of the rock at sunrise can be compared to a photograph taken later in the day from the same direction (Figure 35). Note that the colour of the sky has also changed.

Figure 35: Photographs of Uluru – Ayers Rock – taken at sunrise (left) and midday (right).

More subtle differences can be seen in less extreme situations. Lake Jualbup is part of the chain of wetlands along the coast of Western Australia. The lake has been made the centrepiece of a small park in an inner-city suburb of Perth. The photographs in Figure 36 were taken over a period of three days.

(a) 13:00 30th August 2015

(b) 12:50 31st August 2015

(c) 17:00 29th August 2015

(d) 12:55 31st August 2015

Figure 36: Photographs of Lake Jualbup in suburban Perth.

Figure 36a was taken in the middle of the day in bright sunlight (hard light). Figure 36b was taken at about the same time on the next day when the sky was overcast (soft light). Figure 36c, taken in the late afternoon when the sun was low, can be compared with Figure 36a. While the light is still hard its colour is noticeably different and the trees look more yellowish as a result.

Figure 36d was taken a few minutes after Figure 36b. I was caught in a heavy shower of rain which has had two striking effects: The rain has formed a mist between me and the trees which has changed their appearance. But this did not lead me to think that the trees had changed colour. As with the example of the cloud of exhaust and the policemen's trousers quoted above, I could discount the effect of the rain and see that the colours were the 'same' as they had been when I took the previous photograph. The water also appears different; it has a texture from the impact of the rain drops and the reflection has disappeared. The clarity of the reflections can be compared in the other three photographs. Ripples on the water from the wind also gives the water a texture which blurs the reflection. The reflection is clearest in Figure 36c when the wind had dropped.

On a smaller scale, and more readily accessible, leaves are a particularly good subject for exploring the different aspects of appearance that are plotted in the model above (Figure 26). The leaves in Figure 37a are translucent so their colour can be seen as they transmit light as well as when they reflect light. The leaves in Figure 37b are opaque, very slightly glossy and finely textured. The leaves in Figure 37c are also opaque, highly glossy and smooth.

(a) (b) (c)

Figure 37: Photographs of leaves taken in Kings Park, Perth.

Drawing and photography can focus your attention but you can choose to pay attention whenever you like. Wherever you are and whatever you are doing there are rewards to be had from just looking – at the play of light and at juxtapositions of shapes, colours, textures and cesias. When an interviewer asked Bridget Riley who had inspired her in her career as an artist she gave first credit to her mother [46]:

My mother took us for walks on the cliffs. She was always pointing out colours: in the sea; the sparkle of dew; changes of colour when the dew was brushed away. If she arranged anything on the table like a bowl of fruit … she would point out the colours. … She wasn't a painter, she was a 'looker'. The pleasure that one could get from looking was part of her personality.

Conclusions

The range of possibilities for artists and designers and our ability to appreciate their work as well as our surroundings can be expanded in many ways. The work of artists like Howard Taylor and Bridget Riley can make us more aware of visual phenomena and encourage us to pay closer attention to what we see in the world. The way we perceive things is clarified when we appreciate the distinctions between the different modes of appearance. New words like cesia focus our attention on particular qualities for which we had no name before. Models like those presented here can provide a framework for the different dimensions of light and appearance and can help us to appreciate relationships and possibilities.

Having begun with whiteout and death I will end with visual richness and an affirmation of life. In her short essay The Pleasures of Sight Bridget Riley [17 p.30] explains how she discovered, at an early age, what 'looking' can be. She describes her experiences as a child growing up in Cornwall:

> *– Swimming through the oval, saucer-like reflections, dipping and flashing on the sea surface, one traced the colours back to the origins of those reflections. Some came directly from the sky and different coloured clouds, some from the golden greens of the vegetation growing on the cliffs, some from the red-orange of the seaweed on the blues and violets of adjacent rocks, and, all between, the actual hues of the water, according to its various depths and over what it was passing. The entire elusive, unstable, flicking complex subject to the changing qualities of the light itself. On a fine day, for instance, all was bespattered with the glitter of bright sunlight and its tiny pinpoints of virtually black shadow – it was as though one was swimming through a diamond.*

References

1. Green-Armytage P (1993), Beyond colour, *Proceedings of the Seventh Congress of the International Colour Association (AIC Colour 1993)*, **A**, 155-162, Budapest (Hungary).
2. Green-Armytage P (1993), Future directions for research – colour combinations and total appearance, *Proceedings of the National Conference of the Colour Society of Australia (Colour in Flux)*, 73-85, Adelaide (Australia).
3. Green-Armytage P (1993), Tincture – A new/old word for the appearance of things, *The Journal of the School of Design*, **2**, 16-23, Curtin University of Technology (Australia).
4. Green-Armytage P (2011), A model to link different modes and different aspects of appearance, *Proceedings of the Midterm Meeting of the International Color Association (AIC 2011 Interaction of Colour and Light)*, 165-168, Zurich (Switzerland).
5. Mahon P (1984), *Verdict on Erebus*, 296, Auckland: William Collins Publishers Ltd.
6. Kaiser P and Boynton R (1996), *Human Color Vision*, 2nd edition, 357, Washington: Optical Society of America.
7. Ruskin J (1991/1857), *The Elements of Drawing*, 18, London: The Herbert Press.
8. Dufour G (2003), *Howard Taylor Phenomena*, 19, Perth: The Art Gallery of Western Australia.
9. Matisse H (1978/1908), Notes of a Painter, in *Matisse on Art*, Matisse H and Flam J (eds.), 37, Oxford: Phaidon.
10. Heron P (1974), The shape of colour, *Studio International Journal of Modern Art*, **187 (**963), 65-75.
11. Committee on Colorimetry Optical Society of America (1953), *The Science of Color*, 148, New York: Thomas Y Crowell Company.
12. Katz D (1935), *The World of Colour*, London: Kegan Paul, Trench, Trubner & Co., Ltd.
13. Ackroyd P (2009), *Venice Pure City*, 233, London: Chatto & Windus.
14. https://www.timeshighereducation.com/features/culture/paul-klee-making-visible/2008214.article – last accessed 27 May 2016.
15. Bromfield D (1993), Taylor hones quest for the meeting of nature and mind, *The West Australian*.
16. Snell T (1993), Art in Perth, *The Australian*.
17. Riley B (1999/1984), The pleasures of sight, in *The Eye's Mind: Bridget Riley*, Kudielka R (ed.), 30-34, London: Thames and Hudson.

18. Wright WD (1983), Basic concepts and basic attributes, *Colour Report F28 of The Forsius Symposium on Colour Order Systems and Environmental Colour Design*, 36, Stockholm (Sweden).
19. Hesselgren S (1983), Why colour order systems, *Colour Report F28 of The Forsius Symposium on Colour Order Systems and Environmental Colour Design*, 29, Stockholm (Sweden).
20. Kuehni R and Schwarz A (2008), *Color Ordered*, 108-109, New York: Oxford University Press.
21. Albert-Vanel M (1990), Systems: planetary color, in *The Color Compendium*, Hope A and Walch M (eds.), 286-287, New York, Van Nostrand Reinhold.
22. Albert-Vanel M (2013), The planetary colour system, *Proceedings of the Twelfth Congress of the International Color Association (AIC 2013 Bringing Colour to Life)*, 485-488, Newcastle upon Tyne (UK).
23. Albert-Vanel M (2013), Application of the planetary colour system, *Proceedings of the Twelfth Congress of the International Color Association (AIC 2013 Bringing Colour to Life)*, 1181-1184, Newcastle upon Tyne (UK).
24. Albany J (2009), Between glare and abysmal dark – toward a conversation on colour appearances, *Proceedings of the Eleventh Congress of the International Color Association (AIC 2009)*, 1181-1184, Sydney (Australia).
25. Wright WD (1967), *The Rays Are Not Coloured*, 6-7, London: Adam Hilger.
26. Horowitz F and Danilowitz B (2006), *Josef Albers: To Open Eyes*, 73, London: Phaidon Press Limited.
27. Shea A (2008), *Reading the OED*, 208, New York: Perigree.
28. Manzini E (1989), *The Material of Invention*, 17-18, Cambridge, Mass: The MIT Press.
29. Caivano JL (1991), Cesia: A system of visual signs complementing color, *Color Research and Application*, **16** (4), 258-268.
30. Caivano JL (1993), Appearance (Cesia): Variables, scales, solid, *Proceedings of the Seventh Congress of the International Colour Association (AIC Colour 1993)*, **B**, 89-93, Budapest (Hungary).
31. Caivano JL (1991), Appearance (Cesia): Construction of scales by means of spinning disks, *Color Research and Application*, **19** (5), 351-362.
32. Janello C (1963), Texture as a visual phenomenon, *Architectural Design*, **33**, 394-396.
33. Whitten DGA and Brooks JRV (1972), *The Penguin Dictionary of Geology*, Harmondsworth, Middlesex: Penguin Books.
34. http://www.cybercollege.com/tvp027.htm – last accessed 27 May 2016.
35. Billger M (1999), Colour in enclosed space, *Doctoral Dissertation*, Chalmers University of Technology, Gothenburg (Sweden).
36. Hårleman M (2009), Daylight influence on indoor colour design, in *Colour for Architecture Today*, Porter T and Mikellides B (eds.), Abingdon, Oxon: Taylor and Francis.
37. Green-Armytage P (1992/1989), Colour and other aspects of appearance, *Spectrum – Newsletter of the Colour Society of Australia*, **6** (3), 1-11. [First presented at the National Conference of the Colour Society of Australia, Melbourne, 1989]
38. Evans R (1974), *The Perception of Color*, New York: Wiley.
39. Da Pos O (2004), When do colours become fluorent?, *Proceedings of the Interim Meeting of the International Colour Association (AIC 2004 Color and Paints)*, 308, Porto Alegre (Brazil).
40. Thompson DE (1995), *The Concise Oxford Dictionary*, Oxford: Oxford University Press.
41. Hutchings J (1977), The importance of visual appearance of foods to the food processor and the consumer, *Journal of Food Quality*, **1**, 267-278.
42. Hutchings J (2012), Quantification of scene appearance – a valid design tool?, *Color Research and Application*, **37** (1), 44-52.
43. Kobayashi S (1981), The aim and method of the color image scale, *Color Research and Application*, **6** (2), 93-107.
44. Kobayashi S (1998), *Colorist*, Tokyo: Kodansha International.
45. Wittgenstein L (1977/1951), *Remarks on Colour*, 5-7. Oxford: Basil Blackwell.
46. Henriques N (1999/1988), Personal interview, in *The Eye's Mind: Bridget Riley*, Kudielka R (ed.), London: Thames and Hudson.