H10: Description of Colour

Appearance of objects and materials

Appearance attributes can be split into primary and secondary parts, as shown in Table 1.

Table 1: The attributes of the appearance of a surface

Primary attributes		***Secondary attributes***
Primary attributes directly describe the visual appearance of a coloured surface.		Secondary attributes influence the perception of the primary properties.
Colour;	hue, intensity, lightness	***Size and shape***
Translucency;	transparent, turbid, opaque	***Neighbouring colours***
Gloss;	glossy, matt	***Background colour***
Brilliance;	metallic, solid	
Texture;	rough, smooth	

Colour is a term used for a particular part of the description of the appearance of an object. Colour is not a property of light, colour is a sensation perceived by the brain in a similar way to sound, touch, smell and taste. In part of this module we will be looking at how colour is created.

Whether natural (blue skies, green grass) or man-made (printed paper and board, dyed fabrics, paints, pigmented plastics), most colour types of colour sensation arise from the interaction of light with the optical properties of the molecules and structures present in the material.

Language of colour

A large number of colour terms are in common use to describe different aspects of the colour sensation; to investigate just how many different colour descriptions terms can be used, try Activity 1.

Activity 1:

Think of at least 5 different words that can be used to describe the colour of the patch shown in Figure 1.

Figure 1: Describe the Colour

Colour science suggests that a ***minimum*** of three terms must be used to provide a full description of a colour sensation. Try to place each of the words you used in Activity 1 into one or more of the following three categories.

1. A description of hue
2. A description of lightness or of brightness
3. A description of the intensity of the hue sensation.

There are several types of colour description term in common use

Visual terms such as	light or dark, strong or weak, orange or blue
Emotional terms such as	warm or cool, exciting or soothing
Colour mixing terms such as	dirty or clean, strong or weak
Industry specific terms such as	pasty or deep, fuller or thinner

Strictly speaking, the correct terms to use depend on the how the appearance is being judged and the purpose of the judgement. Establishing common and agreed methods of describing colour is an essential part of noting and communicating colour. This section describes the standard terms that are used in the colour using and colour creating industries.

Most colour scientists agree that six attributes can be identified in the descriptions of colours and these are listed in Table 2. Notice that the description of the attribute of saturation, suggests that is a combination of chroma and lightness.

Table 2: The attributes associated with the perception of a colour

Attribute	**Description**	**Example**
Hue (absolute)	Similarity between the colour of the object and the primary sensations (red, yellow, green, blue)	reddish, greenish blue
Colourfulness (absolute)	The intensity of the hue sensation	neutral, colourful
Chroma (relative)	Colourfulness compared to the brightness of a white viewed under the same conditions	intense, strong, saturated
Saturation (relative)	Relative proportion of colourfulness to brightness of the stimulus	pale, weak, pastel
Brightness (absolute)	Size of response from light sensitive cells	bright, dim
Lightness (relative)	Brightness compared to that of a white viewed under the same conditions	light, dark

Colour and context

The link between colour impression and quality is very strong; this can be illustrated by trying Activity 2.

Activity 2: What is wrong with the items shown in Figure 2?

Figure 2: What's wrong with the items in this picture?

The way in which coloured objects are described and the judgment of their quality is dependent on the nature of the items being viewed and on our expectations. This can be illustrated by considering a prestige product such as a car, Figure 3.

From a distance

The colour variation from a distance is acceptable as the viewer ***expects*** the colour impression to change with the changing orientation of the car surfaces relative to the light source and the eye.

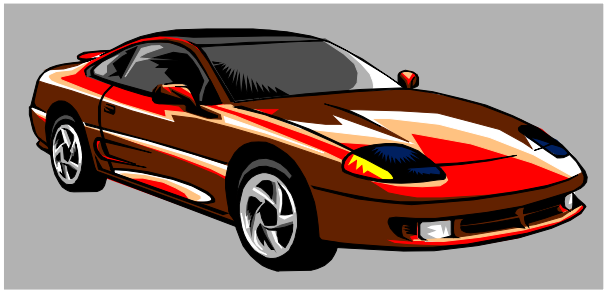

Figure 3: Colour variation from shape and orientation

Close up

When the panels are viewed in close-up, neighbouring panels are ***expected*** to be the same colour. A small colour difference between neighbouring body panels is quickly noticed by the customer and reported as a fault.

The influence of context is clear; the customer readily accepts the different colour impressions when viewing the car from a distance, even when these can be many times greater than an unacceptable degree of colour difference between adjacent body panels.

The cost of a colour difference

It can be expensive to correct the colour of an off-shade finished product, not just in terms of wasted materials but also in terms of the time involved. A hidden cost for a supplier is the loss of good will of the customer. It is vital that colour errors are caught early in a production process it follows that colour control procedures need to present at every stage of production. Whether this control is based on instrumental or visual methods, common and agreed methods of describing colour form an essential part of all of the following tasks.

- The specification of the standard colour.
- The description of the colour difference between a trial and a standard.
- Giving the reasons for rejection of the colour of a trial.
- Specifying the changes in colour to correct an off-shade material.
- Completing the acceptance of the colour of a trial.

Standard colour terms

To specify a colour, or a colour difference, a minimum of one term from each of the three categories has to be used. For example a full description of a colour difference would be:

The trial is lighter, yellower in hue, and more intense (or stronger) than the standard.

The use of emotional terms such as warmer, more vibrant is not appropriate since they can mean something different to each person.

The standard terms that will be described are most often used for reflective surfaces such as paint, printed paper or card, plastics and textiles.

Colorimetric terms are a description of the visual colour sensation ***only*** and not the way colours are created or adjusted by mixing pigments, dyes, inks or paints together.

Colourists' terms are practical terms that are often based on the way the appearance of paint, ink or other material will change with alterations in the mixture of components in the material.

Hue

The quality we use to distinguish one group of similar colours from another

Hue is the term for the name of a colour or of a colour family. For example, if two red objects are being compared and one is judged yellower than the other then a judgement of the difference in hue is being made.

Hue circle

The hues can be placed in a sequence that smoothly changes from one member to the next, to form a circle, as shown in Figure 4. The order that is most commonly used is Red, Orange, Yellow, Green, Blue, Violet and back to Red. The same as the sequence of colours in a rainbow, although Newton included a seventh colour "Indigo" in his rainbow.

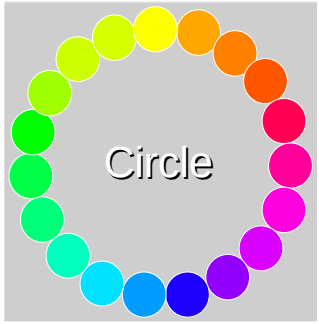

Figure 4: The hue circle

Figure 4 shows the arrangement with the order of red, yellow, green and blue running anti-clockwise around the circle. This the same sequence as in the CIE L* a* b* colour system, an international standard for the numerical specification of colours.

Isaac Newton was the first person to show that white daylight can be split into light of different colours. Newton initially said there were five colours, Red, Yellow, Green, Blue and Violet. A short time later he added two more hues, orange and indigo to give a total of seven, in agreement with the seven notes in the musical scale Do Re Mi Fa Sol La Ti (and back to Do). It was to achieve symmetry with music that the extra two colours were added, although most people can only identify six of the colours when directly viewing a rainbow. It was unthinkable for a rainbow to have six colours, since the number 6 was associated with the devil.

Unique hues

It is interesting to ask the question:

"Are all hues of equal importance, or are some hues special?"

One way of testing is to conduct the imaginary experiment given in Activity 3.

Activity 3:

Imagine you are talking to a colleague on the telephone and you have to describe the colour of the patches in Figure 5.

Consider whether you could describe the colour without using the hue name next to the patch.

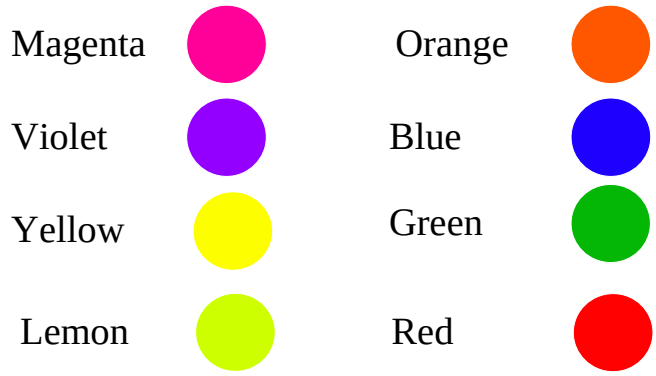

Figure 5: Try to describe the colours without using the hue name

Psychological primaries

It soon becomes clear that the colours represented by most of the hue names can be described using alternative hue terms. There are four hues that cannot be described using other words and this is the reason that they are called the psychological primary colours, they are:

Red and Green, Yellow and Blue

Any hue may be described in terms of one or at most two terms drawn from these four. When two terms are used, one term will be drawn from each pair. For example orange is a not a unique hue since it can be described as a red shade of yellow, in a similar way purple is not unique since it can be described as a red shade of blue. The primary hues Red, Yellow, Green and Blue are unique since they cannot be described by using alternative hue terms.

Opponent pairs of colours

Red and Green form an opponent pair of colour sensations. Look around the room, outside in open, through a magazine, search through a pattern card or a colour atlas, you will ***never*** find a patch that you describe as having both the properties of redness and greenness. There is no such colour as a red shade green. In the same way, Yellow and Blue are an opponent pair of colour sensations. Each pair can be thought of as forming one axis on a colour chart, as shown in Figure 6.

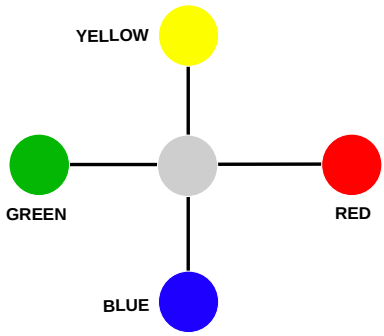

Figure 6: Pairs of opponent colours

This arrangement is similar to the colour chart used in the CIE L* a* b* system of specifying colour.

Hue is the term used to describe the similarity between a colour and one or more of the primary sensations red, yellow, green or blue.

Lightness

The quality we use to distinguish lighter shades from darker ones.

Lightness, a "relative" term

When terms such as white, black, and mid-grey are used to describe neutral objects the appearance property of lightness is being described. The adjectives light and dark are often combined with a hue name to form "light green" or "dark brown" for example.

Activity 4:

Imagine viewing this as a printed page under three different conditions of illumination, at your desk, in a controlled viewing booth and under a spotlight. Note down a description of each patch under the three conditions. Would your lightness description of the middle patch change as you move the paper from one illumination condition to another or would it remain as "mid-grey"?

The best explanation of the way a "lightness" description stays the same despite large changes in the amount of light reaching the eye is that is a relative term. A mental comparison is being made between the amount of light received from the patch and that received from a perfect white. Both will change by equal amounts as the intensity of the illumination changes. The ratio of the intensity of light reflected by the patch to that reflected by a white will remain the same, in the same way as our description, light grey, mid-grey, dark-grey stayed the same. It is interesting that we seem to be able to do this, even when there is no "perfect white" in the field of view.

Lightness is judged by the brightness of the object compared to that of a white viewed under the same conditions.

Brightness, an "absolute" term

Brightness is the term used to describe the colour sensation as being bright or dim. It is a measure of the ability of the light entering the eye to stimulate the neutral (achromatic) response from the light sensitive cells. In general, the cells are more sensitive to green light than to blue or red light, so that the same intensity (Watts/m^2) of green light will appear much brighter or more luminous than a red or a blue light.

Brightness is commonly, but incorrectly, used in a similar way to lightness. For example, the terms bright green and dull brown might have been used instead of light green and dark brown. The distinction between brightness and lightness can be clarified by an example.

The brightness of the patch depends on the amount of light reflected from the patch into your eyes. The higher the intensity of the lamp the brighter the patch will appear as illustrated in Figure 7.

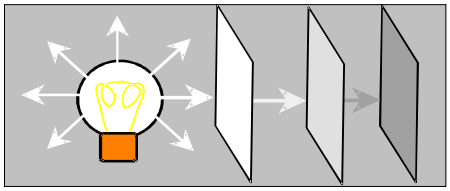

Figure 7: The object looks brighter the closer it is to the lamp

Intensity of colour

The quality we use to distinguish strong, saturated colours from weak, pastel ones.

The intensity of the colour sensation is the third term to complete a set of three. The set of patches shown in Figure 8 change from no colour sensation (neutral grey) to an intense red sensation.

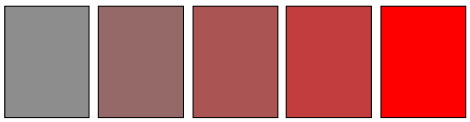

Figure 8: Patches of similar hue and lightness and with increasing intensity of colour

Each of the patches has a similar lightness, they are also similar in hue so the only property that is changing along the series is the intensity of the colour sensation.

There are three standard terms used for the intensity of colour, these are colourfulness, chroma and saturation. Although chroma and saturation terms are often swapped around as if they meant the same thing, they describe different aspects of the intensity of a colour sensation.

Colourfulness

The colourfulness of a colour sensation is difficult to define precisely. It can be thought of as a measure of the concentration of the hue sensation. For example, the colourfulness of a red pepper on a white plate depends on the intensity of the illumination. Under strong daylight, it will appear very colourful, indoors or in the shade, it will appear less colourful. The neutral greys running from white to black, are achromatic, they have zero colourfulness.

The relative attributes of chroma and saturation are used more often and are more easily understood.

Chroma, a relative term

If the red pepper is considered once again, then we know that under strong daylight, it will appear very colourful and indoors or in the shade, it will appear less colourful. However, most observers would judge the strength (chroma) of the colour of the red pepper to be the same under the two viewing conditions. The simplest explanation is that a mental comparison is being made between the colourfulness of an object compared to the brightness a white would have when viewed under the same conditions. The best explanation of the way we use terms such as a “strong” colour or a “weak” colour is that chroma is a relative term.

Chroma is judged by the colourfulness of an object compared to the brightness of a white viewed under the same conditions.

As the intensity of the illumination changes, the brightness of the white plate, on which the red pepper stands, will change by a similar proportion to the colourfulness of the pepper. Both properties will change by equal amounts. The ratio of colourfulness of an object to the brightness of a white remains the same, as does the chroma descriptions such as strong or weak, deep or pastel.

Saturation

The term saturation is often wrongly used in the same way as chroma. Strictly speaking, saturation describes the relative proportion of the colourfulness to the brightness of the colour sensation. For example, viewing two light sources that differ only in intensity would give different perceptions of brightness and colourfulness. However, the two sources would have the same saturation. The most saturated colour sensation is from light of a single wavelength known as monochromatic light.

Saturation is judged by the colourfulness of an object compared to the brightness of the object.

Summary

There are three terms needed to describe the colour appearance of object.

Hue The quality we use to distinguish one group of similar colours from another. Hue is the term used to describe the similarity between a colour and one or more of the psychological primary sensations red, yellow, green or blue.

Lightness The quality we use to distinguish lighter shades from darker ones. Lightness is judged by the brightness of an object compared to that of a white viewed under the same conditions.

Chroma The quality we use to distinguish strong, saturated colours from weak, pastel ones.