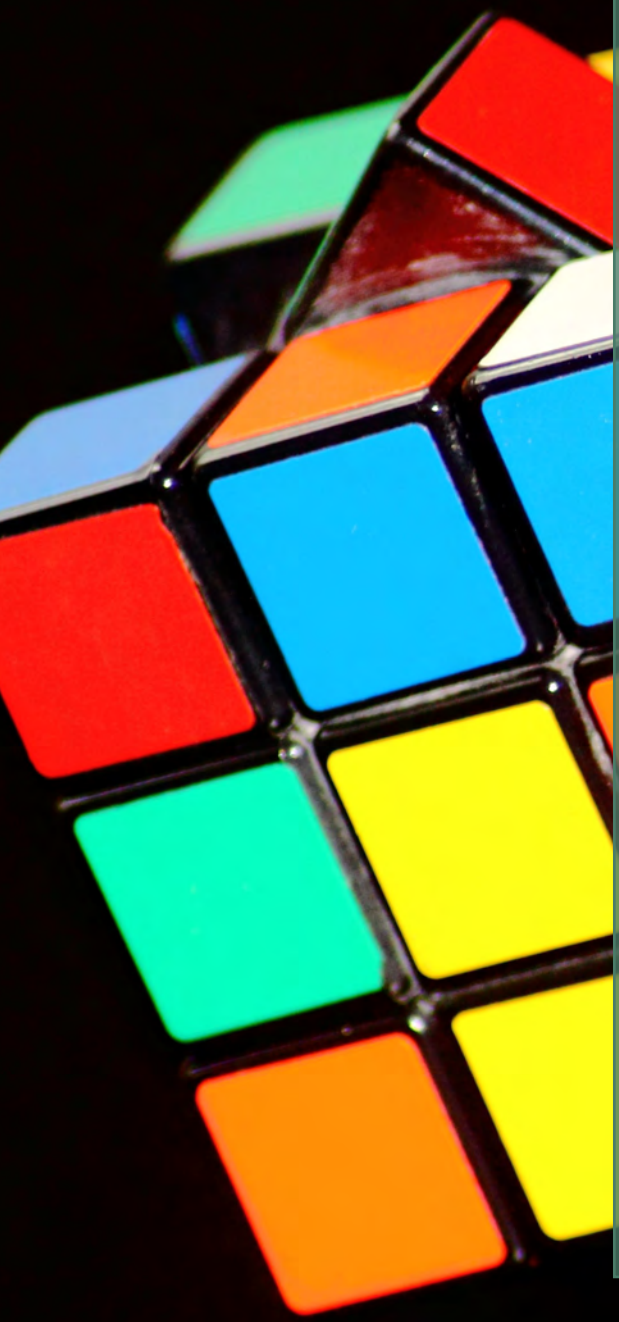
THE COLOUR OF MAGIC

Metamerism



Imagine. You put a lot of effort at home that morning to coordinate the colours in your art project. You used different materials and you matched the colours of textiles and paints. Then you went back to your room in the evening to continue your project only to realise when you switched on the lights that the colours don't match!

Disaster! Why did this happen after all the care and effort you put into getting your art project to look the way you wanted it?

To answer this question, we first need to think about how we see colour. There are three components that affect the colour we see: a) the light source, b) the physical or chemical properties of the object which reflects (or transmits) the light and c) our human visual system. All these components have colour properties. The colour of the light source depends on its energy at different wavelengths (*spectral power distribution*). When the light falls on the surface of the object, the amount of light that is reflected depends on its wavelength (this is known as *spectral reflectance*). The reflected light reaches our eyes and the red, green and blue photoreceptors in our eyes contribute to the sensation of colour. Your blue t-shirt reflects mainly short wavelengths while the red ink from your pen reflects mostly long wavelengths. All colours we see are made with a mixture of wavelengths from the visible spectrum.

KEY IDEAS

You may now think that for the colours of two objects to match under the same light source, they should have the same spectral reflectance. But this is not always the case. We may have two colours with different spectral reflectance that appear to be the same when viewed under the same lighting source. These colours are known as *metamers* and the effect as *metamerism*.

How can these colours match if they don't reflect the same wavelengths? Remember that the colour we see depends not only on the object but also on the spectral power distribution of the light source and the response of the human visual system. Because colour is perceived from the stimulation of the red, green and blue photoreceptors in our eyes, two objects may produce the same colour sensation when their spectral reflectance is combined with the spectral power distribution of the light source. What happens if we change the light source? The colours of the objects may no longer match. This is known as *illuminant metamerism*. Look at the two photographs to the right: The cardboard box and the crystal tumbler appear to have the same purple colour under LED lighting. When the light source is changed to fluorescent, the colours look very different.

There are also variations in colour vision between individuals which may result in another type of metamerism, known as *observer metamerism*. In this case, we may have two objects with different spectral power distributions under the same light source which appear as having matching colours to one observer and different to another.

Metamerism is useful in many applications. Just think of how colour is reproduced and take photography as an example. Digital cameras capture images using a sensor with pixels covered with red, green, and blue filters. All the colours in our photographs are reproduced by combining different amounts of these three colours. When we print our photographs, the colours are reproduced with cyan, magenta, yellow, and black inks. The reproduced colours result in approximately the same visual sensation as the original subject but they don't have the same spectral properties.

Metamerism, however, can be a problem for different industries. One example is the textiles industry. You may have come across this when you bought clothes with colours that matched in a shop, only to find that they no longer matched when you wore them outdoors, under daylight. Another important example is in the automobile industry, where manufacturers put a lot of effort into choosing the paints for the exterior and interior parts of a vehicle so that they match under different lighting conditions.

Metamerism can be measured in the industry using special devices. In our everyday life, however, a practical way to avoid mismatch due to metamerism when we match textiles or paint samples, for example, is to view them under several different light sources, both indoors and outdoors, and to see if they still match.

KEY READINGS

BBC Bitesize (No date). *Visible light and colour* Available from: bbc.in/39Poplr

Fairchild, M. D. (2013). *Color Appearance Models.* 3rd ed. Chichester: John Wiley & Sons, 335-336.

Langford, M. and Bilissi, E. (2011). *Langford's Advanced Photography.* 8th ed. Oxford: Focal Press, 1-23.

ACTIVITIES

1. Can you give examples of applications where metamerism is useful?
2. Think now of industries where metamerism can be a problem because the colours of different materials have to match, and give some examples.
3. Think of art and discuss ideas of how you could use metamerism creatively. Why not try creating an artefact out of this?

These resources are produced by the University of Westminster School of Media and Communications. This topic was developed by the EPQ team and **DR. EFTHIMIA BILISSI,** the Westminster School of Media and Communication, University of Westminster. Image by DomenicBlair from Pixabay.

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