Lesson 19

Other Colour and Vision Phenomena: Afterimages; Colour Constancy

■ Afterimages

An ***afterimage*** is an image briefly 'seen' - rather, experienced by the brain - after the original light stimulus (original 'image') is removed from the visual field.

The fact that we 'see' afterimages in opponent colours of the original images is another example supporting the opponent processes of colour vision in the brain.

■ The Physiology of Afterimages

What is the physiology behind afterimages?

• When we stare at a specific colour (say red) for some time, the *opponent cells* responsible for the 'red' colour determination (based on output rates from the Lcones) will become 'over-saturated' ☿ *'fatigued' red cells*

• If we now look over to a 'neutral' background (such as white), from which light (photons) of *all* wavelengths are

entering our eyes, these fatigued red cells will 'under-detect' the redness of this neutral-background image, by responding slower to the output of the L-cones than they should ☿ *under-detection of redness in image*

• The brain will compare the slower response rate of the fatigued red cells against the rate coming from the green opponent cells, determining the image to be more green than red ☿ *green-ish afterimage is briefly experienced*

• this effect lasts only for a few seconds right after staring at the initial red colour, until the opponent cells return to their normal responding rates

■ Variations in Afterimages

To experiment further with afterimages and their intensity, try these variations:

• neutral backgrounds such as white or grey in original image (with the coloured shape inside), switched to white background for the afterimage experience

• all-black background in original image (with the coloured shape inside), switched to white background for the afterimage experience

• opponent-colour background in original image (with the

coloured shape inside), switched to white background for the afterimage experience

• other variations?

■ Primary Goal, Problem, and Solution of Colour Vision

Goal:

• to determine the 'true' colour of objects (surfaces)

• *example: bananas are yellow, strawberries are red*

Problem:

• objects are seen under a wide range of illuminants (light sources), meaning different amounts of wavelengths of light could be falling on an object

• *example: variance in natural light; artificial lights*

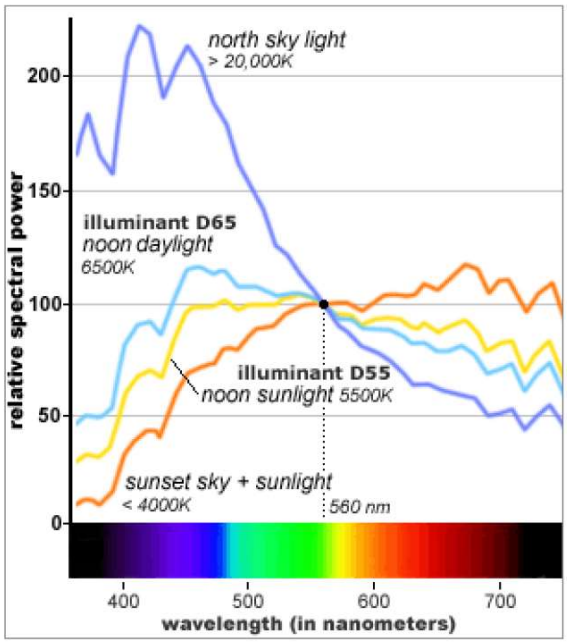
Solution:

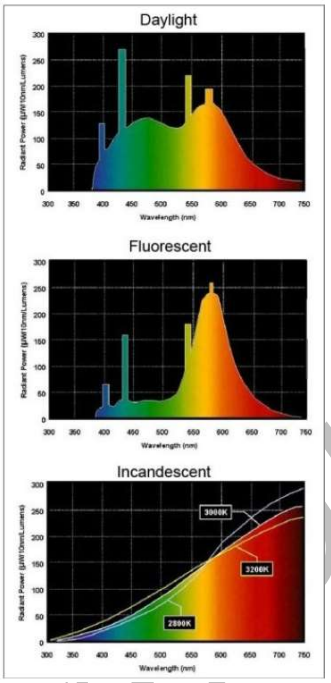
• discount the variance in illuminants, with the mechanism of colour constancy

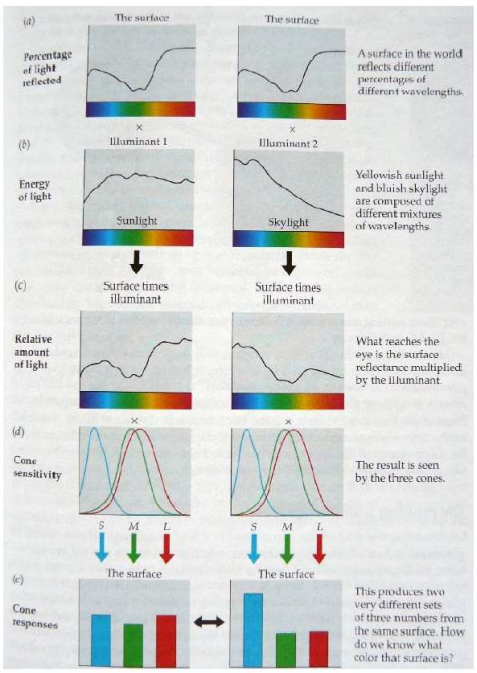
• ***colour constancy*** allows for the object's colour to appear constant under a range of illuminants, based on assumptions made by the visual system

• *example: bananas will appear yellow at noon, sunset, or in artificial light*

■ Variance in illumination: natural & artificial







The variation in lighting sources falling on the same two surfaces (or, same physical objects with ***the same reflectance properties***) can result in different cone stimulations.

Yet, somehow, the visual system has been 'trained' to keep our perception of such surfaces as same colour under a wide range of such illuminants with the with the mechanism of **colour constancy**.

■ Colour Constancy

Colour constancy allows for the object's colour to appear constant under a range of illuminants, based on assumptions made by the visual system.

In other words, the visual system has adapted to discount the variance in the illuminant, in favour of keeping the object appearing the same colour.

These assumptions are about:

• the nature of the ***illuminant***

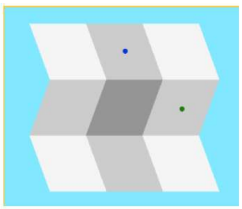
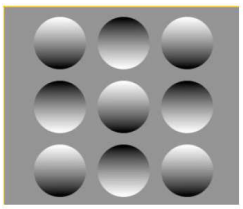
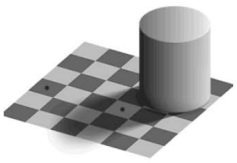
• broad spectrum of wavelengths

• distinguishing sharp vs fuzzy edges

• the nature of the ***object***

• broad reflectance spectrum

■ Assumptions about the illuminant: Examples

Visual Disorders: Colour Deficiency

Colour Blindness vs Colour Deficiency

The term '*colour blindness*' is rather misleading – there is only one type of eye disorder that results in 'true' colour blindness (inability to see/distinguish ANY hues at all), giving only light/dark contrast vision. This is extremely rare (1 in

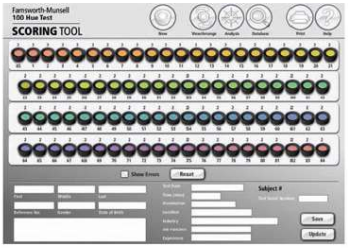
100,000 people).

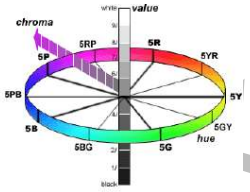
The rest of colour vision disorders will still produce some form of colour vision (perception of hues) – it is just a *different* type of colour vision/perception than that of 'normal' colour vision. Therefore, it should more appropriately be called '*colour vision deficiency*', rather than colour blindness.

Normal Colour Vision

'Colour deficiencies' can only be spoken of in terms of how people perceive colours differently from some kind of a 'normal' colour vision standard. How do we define such a 'normal colour vision' standard? And how can we test what kind of colour vision YOU have, compared to this 'normal' standard?

By cataloguing many different people's colour identification sequences, we have created a 'standard' colour reference set, which uses the Munsell colour system of hues at constant saturation, under daylight illumination.





The *Farnsworth-Munsell 100 Hue Test* is a colour-testing standard used in the colour industry, to score an individual's particular colour vision against this 'normal' standard.

■ Causes of Colour Deficiencies

The are two main categories of causes of colour deficiencies:

ACQUIRED

- damage to retina / optic nerve / brain
- aging
- eye diseases
- side-effects of medications

INHERITED

- deficiencies in cones and their functionalities
- deficiencies in visual processing in the brain *(even if cones are fine)*

In total, approximately 8% of males (1 in 12) and 0.5% of females (1 in 200) report some sort of colour deficiency.

■ Types of Colour Visions

The most common types of colour deficiencies arise from problems in the functionality of the cones in our eyes.

Trichromacy – 'normal' colour vision that relies on the proper functioning of 3 types of cones, each with a different spectral sensitivity range, to distinguish the over 10,000,000 variations in colour/brightness/saturation.

(*Note*: even with 3 types of cones present/functioning, there can still be 'partial' colour deficiencies when certain portions of cone population are affected).

Dichromacy – the most common type of colour deficiency, where mainly one type of cone is not functioning or absent altogether. The resulting colour perception/vision is made with 2 types of cones only ☿ 'different' colours!

Monochromacy – true 'colour blindness', where either only 1 type of cones is present/functioning. The person

will see everything in ‘black-grey-white’, having only light-dark contrast available. This is extremely rare (1 in 100,000) and is inherited from two affected parents.

■ Dichromatic Colour Deficiencies

This is the most common type of colour deficiency. It is more common in males than females because the genes responsible for encoding the proper functions of the M and L cones (most abundant ones) are carried on the sex-linked Xchromosome (of which males have only one: XY, while females have two: XX).

There are 3 types of dichromats:

Protanopia – colour deficiency resulting from lack of, or ‘non-functionality’ of the
L-cones.

Deuteranopia - colour deficiency resulting from lack of, or ‘non-functionality’ of
the M-cones.

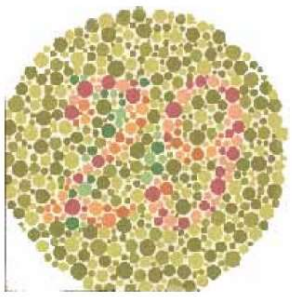
Tritanopia - colour deficiency resulting from lack of, or ‘non-functionality’ of the S-cones.

Out of dichromatic colour deficiencies, the most common ones are those with L or M cones affected

(protanopia/deuteranopia), while S-cone deficiencies (tritanopia) are quite rare (1 in 1,000 for men and women), since they are found on a different, non-sex-linked chromosome.

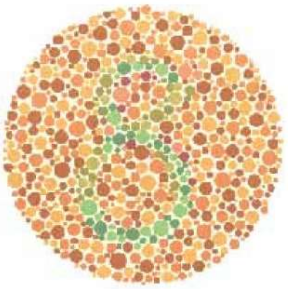
■ Ishihara Test for Red-Green Colour Deficiencies

Another 'specialized' kind of test, to check for red-green colour deficiencies, is called the ***Ishihara Test:*** patterns of **different-coloured, but similarbrightness** dots will appear to have a certain number encoded in them to people with normal colour vision, whereas people with red-green colour deficiencies will not be able to 'see' this correct number, but instead will see a different number or no pattern at all.



Correct number: 29

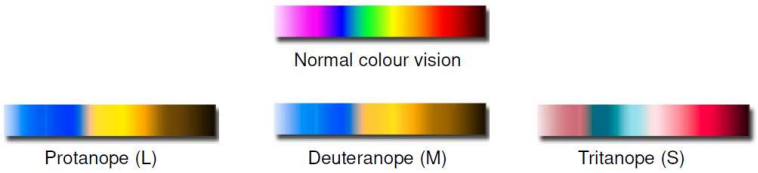
'Deficiency' number: no pattern



Correct number: 8

'Deficiency' number: no pattern

Simulating Colour Deficiency Vision



Visual Disorders: Synaesthesia; Other Disorders due to Brain Damage

Synaesthesia

Synaesthesia: a neurological condition where a person may regularly experience the '*joining*', or 'cross-linking' of two or more *senses* that normally are perceived to be separate. A variety of such cross-linked senses 'permutations' are possible, and have been consistently reported by synesthetes.

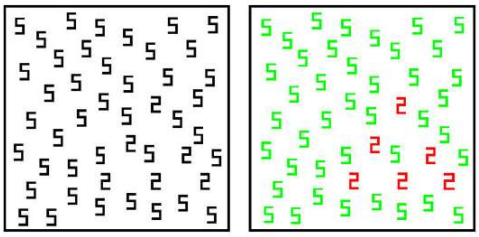
This harmless condition affects about 1% of the population, is hereditary, and seems to be more common in women than men, suggesting it may be a sexlinked genetic trait.

Example: numbers or letters may be associated with certain colours.

Testing for Synaesthesia

Repeated comparison trials done by synesthetes show that it really is an 'automatic' response, rather than a 'learned skill/trick'.

Example:
The *pop out test:* pick out and count the number of 2s hidden in this field of 5s



A non-synesthete ('regular' sensations) will have to scan the entire image to locate and count each single 2; whereas to a synesthete, all the 2s will 'pop out' of the field of 5s much quicker, since they appear in a different colour.

Synaesthesia Research

Research on Synaesthesia began in the late 1800s, with periods of high and low research activity. It has recently been on the rise again, in the modern field of neural and cognitive research, not only for the sake of learning about

synaesthesia itself but also in hopes of learning about how cognitive associations of ‘regular’ senses may develop in ‘normal’ people.

■ Visual Disorders due to Brain Damage

Watch the following parts of the documentary **‘Phantoms in the Brain’**