H35: Visual Assessment of Colour Difference

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The link between colour impression and product quality is very strong especially in a prestige product. 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 the 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 the quality control of the colour of a product is based on instrumental or visual methods, common and agreed methods of describing differences in colour form an essential part of all of the following tasks.

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 needed to correct an off-shade material.

The most reliable visual judgement of the colour of a material is made by a direct, side-by-side comparison of the colour of the test panel with the colour of the sample panel, as illustrated in Figure 1.

There are a number of factors that influence the decision and need to be controlled in order to obtain accurate and repeatable evaluations of the colour difference between a trial and a standard.

Even under the best conditions, for samples with colour differences typical for the commercial production of products, an individual observer will disagree with the decision of the majority of a group of observers about 17% of the time.

Three factors need to be considered and controlled;

the presentation of the test panels;

the viewing conditions;

the observer.

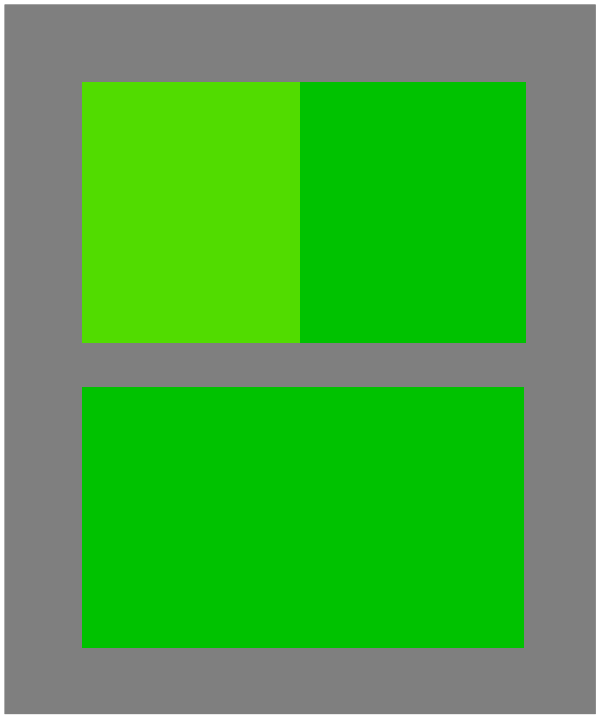

Figure 1: A large colour difference and a small colour difference

Describing differences in colour

Colour is normally described in terms of lightness, intensity of the colour sensation and hue. It follows that to characterise the difference in colour between a product and a standard, 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 or more vibrant is not appropriate since they can mean something different to each person. In a similar way the use of industry specific terms, such as cleaner or pasty, should be avoided.

The standard terms used for reflective surfaces such as paint, printed paper or card, plastics and textiles are those also used in the instrumental method of colour assessment, which is based on the CIE L* a* b* equation. These terms are a description of the visual colour sensation ***only*** in, these terms are known as colorimetric terms.

Colorimetric terms Terms that refer to the visual sensation created by a coloured surface.

Visual assessments of colour difference are often given in industry specific terms that tend to describe the way colours are created or adjusted by mixing pigments, dyes, inks or paints together, these terms are known as colourists' terms.

Colourists' terms Practical terms based on the way the appearance of a coloured material changes with alterations in the mix of colorants.

By adopting the colorimetric terms for both visual and instrumental methods, a comparison between visual and instrumental decisions becomes straightforward.

Graphic images

The judgement of the colour quality of graphic images is more difficult to assess. Usually the pass-fail decision is based on the overall impression from the image rather than any one specific coloured area. A common method of visual judgement is to agree a standard print and a series of prints that represent the limits of acceptability along the colour change types. An example of this approach is shown in Figure 2, where a lighter print limit and a darker print limit is provided as well as the standard print.

Figure 2: Limits of acceptable product colour

Panel presentation

Panel size

Where possible it should be arranged for the trial panel and the standard panel to be of sufficient size for the image to cover an area on the retina equivalent to the 10°degree standard observer area.
A square panel of side 5.0 cm (2 inches) viewed from a distance of about 50cm satisfies this condition.

It is important that the trial panel and the standard panel are the same size. When this is not the case then the panels should be viewed through a mask made from mid-grey card ($40 < L^* < 60$) with a hole cut in the card so that equal areas of trial and standard are visible.
Explanation: The mixture of light sensitive cells changes and the light filtering effects of the overlying layers changes with the position in the retina.

Panel separation

The most sensitive test of colour difference is when the trial panel and the standard panel are next to each other, in edge-edge contact.

Explanation: The slightest gap between the edges, even as little as 1mm, will increase the visible threshold of colour difference but up to 50%, as illustrated by Figure 3.

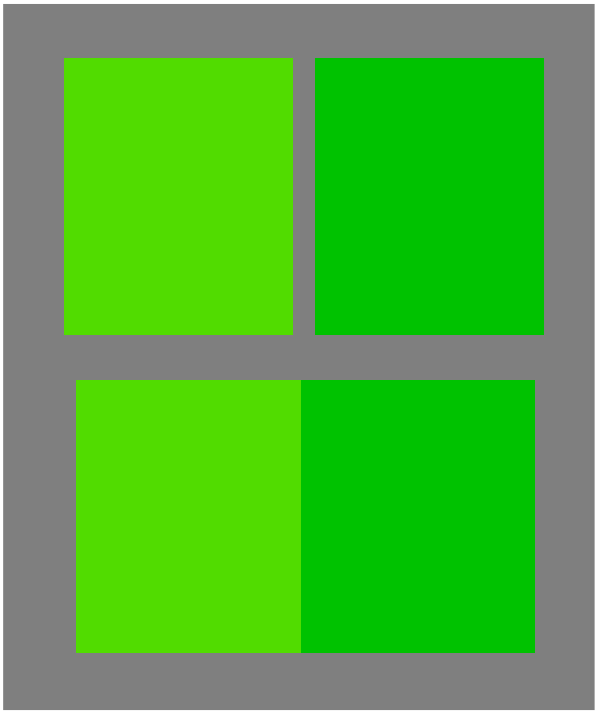

Figure 3: A gap reduces the visual sensitivity to colour difference

Illumination type, and level

Type

The panels should be viewed under lamps that provide a good simulation of the CIE standard illuminants. Normal practice is to make judgements under:

A daylight illuminant D65, however the graphics industry normally uses D50;

The illuminant under which the illuminant will normally be viewed, such as warm white fluorescent (home) or cool white fluorescent (office or factory);

At least one other illuminant with a very different type of spectral distribution, such as illuminant A.

Explanation: Choosing to view the panels using a simulated CIE Standard Illuminant will allow the visual decisions to be directly compared with the instrumental measures of colour difference. Examination under three different types of illuminant will allow the colour constancy of the trial panel and the degree of metamerism between the trial and the standard to be judged.

Level

The illumination level should be of order 1000 lux, equivalent to a brightly lit room.
Explanation: The illumination level must be sufficient for only the cone type cells in the retina to be active, photopic vision.

Background and surround

Background

The standard and trial panels should be viewed against a mid-grey background ($40 < L^* < 60$).
Explanation: The colour of the immediate background has an influence on the impression of items of interest; this is clearly demonstrated by the simultaneous contrast effect. By keeping the background as a neutral grey, the extent of the effect will be the same each time the panels are viewed.

Surroundings

The surroundings of the room or area in which the viewing judgements are carried out should not contain large areas of strong colour.
Explanation: The visual system becomes adapted to the average nature of the light in the visual field. Strongly coloured walls and other decoration will influence the state of adaptation of the visual system.

Light cabinets

Many of the conditions are achieved most simply by purchase and use of a suitable light cabinet. There are a number of different types of cabinet available, each type designed for a different type of sample.

The figures illustrate three types of cabinet produced by the Verivide company, having:
a curved viewing area (Figure 4);
a 45° tilted viewing area (Figure 5);
a flat viewing area (Figure 6).

Figure 4: Light cabinet suitable for graphics

Figure 5: Light cabinet suitable for flat panels

Figure 6: Light cabinet suitable for 3d objects

There are some obvious housekeeping rules for the correct use of light cabinets.

The cabinet should be positioned away from large windows or sources of bright light in order to avoid light spilling into the cabinet from the surroundings.

The viewing area should be keep clear of clutter such as old samples, instruction books and so on.

The lamps surfaces or the light diffuser in the luminaire should be regularly checked for dust and cleaned when required.

The lamps should be replaced at the recommended intervals.

Observer

In an ideal situation, the people making visual judgements of colour quality will have normal colour vision and superior ability at discriminating between colours. If possible, their colour vision should be tested at least annually using for example the Ishihara test or the more elaborate Munsell-Farnsworth hundred-hue test.

It is important to recognise that strong medications and recreational drugs can change the nature of our colour vision, as can physical injury such as bang on the head.

Finally, and I hope obviously, a person making colour judgements should not be wearing sunglasses, tinted spectacles or tinted contact lenses of any sort

Nature of the colour pass-fail decision

It is generally accepted that there are two distinct types of pass-fail judgement and these are known as an *"acceptability decision"* and as a *"perceptibility decision "*.

Perceptibility

A perceptibility decision is the simpler of the two; a choice is made between two options

Option 1 ***The colour of the trial is a visual match to the colour of the standard***
There is no visible difference in colour between the trial and the standard.

Option 2 ***The colour of the trial does not match the colour of the standard***
There is a visible difference in colour between the trial and the standard.

When these types of decision are being made then it should not matter which type of material is being judged or whether a customer or a supplier is making the judgment.

Acceptability

An acceptability decision is the type that is normally made when judging the colour quality of commercial products, either by a customer or by a supplier. A choice is made between three options.

Option 1 ***The trial colour is a visual match to the colour of the standard***
There is no visible difference in colour between the trial and the standard.

Option 2 ***The trial colour is an acceptable match to the colour of the standard***
There is a visible difference in colour between the trial and the standard and the difference is judged to be small enough for the trial to be accepted as a colour match to the standard.

Option 3 ***The trial colour does not match the colour of the standard***
There is a visible difference in colour between the trial and the standard and the difference is judged to be large enough for the trial not to be accepted as a colour match to the standard.

The upper limit in colour difference that is judged to be acceptable will depend on the product being considered. The limit will be close to the threshold of visible colour difference for the automotive industry, whereas the limit for a disposable item of low value, such as food packaging, could be two or three times greater than the visible threshold.

Determining the "correct decision"

There is little likelihood of disagreement between observers when the colour of the trial and of the standard are very different from each other ($dE^* \geq 5.0$). Nearly everyone will agree that the "trial colour does not match the colour of the standard", upper pair in Figure 1.

Similarly, when the trial and standard are virtually identical in colour ($dE^* \leq 0.5$), nearly everyone will agree that the "trial colour is a visual match to the colour of the standard", lower pair in Figure 1.

When the colour difference between the trial and the standard is near the boundary of the visible threshold ($0.8 < dE^* < 2.0$), then the observers will not agree in their judgements. The correct decision of whether the colour of a trial panel matches the colour of the standard is the majority decision of a large group of observers. For example if there are 5 judgements that the trial matches a standard and 7 judgements that they do not match, then the correct (majority) decision is that the trial does not match the colour of the standard. In this example 5 out of 12 judgements (42%) disagreed with the majority decision, there were the 42% "wrong" decisions.

Threshold of visible colour difference

There is a characteristic relationship between the colour difference stimulus and the probability of deciding the colours do not match (Reject) as is illustrated in Figure 7.

When the colour difference stimulus is high then the probability of a “Reject” decision is over 0.9. When the colour difference stimulus is low then the probability of a “Reject” decision of less than 0.1. Half way between the two is the point of maximum argument where half of the decisions will be “Reject” and half of the decisions will be accept.

The stimulus at which this “50% : 50%” split in decisions occurs is defined as the visible colour difference threshold.

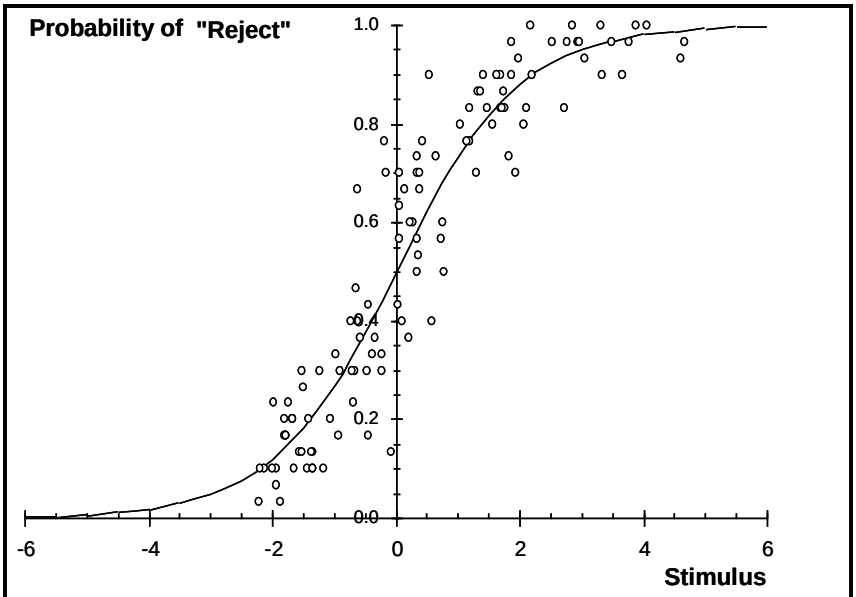

Figure 7: Stimulus response chart for colour difference decisions

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