# The use of Spectrophotocolorimetry Techniques in Modern Art

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## ABSTRACT

**This paper contains a description of the colorimetric assay technique and its use in the conservation and recording of the colours in modern and contemporary paintings. It also gives a description of how the instruments involved should be used and what procedures should be adopted across a variety of cases. Lastly, this paper provides a number of examples of how this technique can be used.**

## Keywords

Modern art, colorimetry, conservation

## 1. Introduction

Some time ago the press agency AIDA, which specialises in cultural heritage, spread the news that the colour yellow in Van Gogh's paintings is changing and that it won't be long before the original colour will no longer be identifiable. It is general knowledge that colour is a question of perception and, as such, cannot be measured objectively. Perception is, however, induced by an external stimulus, namely light, which interacts with the receptors, cones and rod cells of vision. In turn these generate a biochemical stimulus, which, when processed by the mind, leads to the perception of colour. As matter does not generate light itself, it acquires the colour of the light that it reflects. It is, therefore, necessary to observe matter in a standardised light resembling the white light of the sun. Of course, the light we are talking about is none other than electromagnetic waves in the range of what is visible, i.e. with a wavelength from 380 to 780 nanometres, as wavelengths outside this range are not recognised by our receptors. In truth, though these are the basic principles, the physical and biophysical phenomena behind our perception of colour are very complex and lead us to the explanation and interpretation of colorimetry. Spectrophotocolorimetry is a technique developed to identify a particular colour by matching it with an international codified alpha numeric system.

There is significant demand for the employment of this technique in the analysis of paintings, especially where there is to identify a colour before and after restoration work or before deterioration. On most occasions it is possible to identify the pigments used with minimum impact on the painting . However, a determination of the original colour, in terms of reflectance, chroma and saturation is still impossible and the same applies to other elements, such as sheen.

With such techniques in existence for the analysis of old paintings, it seems odd that for the majority of modern paintings data of colorimetric analyses is not available. Such data would, in fact, avoid doubts concerning the nature of the colour from arising in the future. A contemporary painting could be examined in its original condition, thus avoiding the need to wonder about future colour changes – about the white that is now "yellowish". The rules and procedures for this easy, non-invasive and cheap technology are suggested below. Its goal is not only to monitor the deterioration and faithfully reproduce the colours, but also to keep a record of the original colours of a painting.

## 2. Instruments and recording of the data

A spectrophotocolorimeter is none other than an instrument illuminating a surface with a calibrated and standardised light source which measures how much radiation (and of what type of radiation) is reflected by the point or space that is being measured.

The classical theory "tristimulus" lists the three measurements needed to define the colour of an opaque surface: chroma, saturation and reflectance. The measurements should be taken from a suitable reference space. However, at least one more measurement is needed: brilliance or brightness. It would also be useful to measure the goniometric characteristics of the radiation reflected [1]. With a spectrophotocolorimeter these elements are simplified by transforming a physical measurement into scores for the reference point chosen. The choosing of the point is a delicate operation, especially if immediate results are required; if needed the software can recalculate the values of a new point [2]. There are many of these points and they are each chosen from a different application or from various types of material, such as the Yxy space (where Y is reflectance, x the normalised red component and y the green component), the L*a*b* space (the CIE reference standard) and the L*C*h space (where L* is "clearness" from 0 (black) to 100 (white), C* "chromatic vividness" and h, the most important, is the hue angle, which goes from 0° to 360° passing through the perceived colours 0° = red, 90° = yellow, 180° = green, 270° = blue).

The spectrophotocolorimeters for sale are instruments that, in order to cancel out any interference from outside light radiation and to pick up all the reflected radiation, need to be placed perpendicularly and lightly resting on the area to be measured. The area comprises of a circular spot with a diameter of 2 to 25 mm. In the large majority of cases the most suitable size is 3 to 7 mm. Spectrophotocolorimeters are portable and easy to use [3].

Naturally, it is essential that the area measured be recorded for anyone needing to consult the data in the future. Generally, the artwork is photographed and the specific area measured

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(even at a low resolution in black and white). With the use of software such as Photoshop, digital marks are placed to indicate the points or areas where the measurements have been performed. The operating parameters, such as the choice of source of illumination, etc. are standardised and, although they should be indicated, it is common practice to conform to the D65 10° specification suggested by the CIE. Normally a measurement is obtained from the average of at least 5 scores and the statistical data are automatically supplied by the instrument itself.

## 3. Methodology and measuring procedures

The measuring processes need to be adapted to the specific type of work being measured. The following are the most used:

- A dotted area where the colour is homogeneous; such an area cannot be smaller than the spot of the instrument
- A background area with a relatively constant colour
- An area with small variegations with dimensions smaller than those of the instrument spot

The measuring process differs according to which type of work is considered. In case 1 it is a question of repeating measurements with minimal movements of the instrument with overlapping spots and checks on their repeatability. In case 2 there are separated spot measuring points around an ideal point; relevant differences must be checked. In case 3 it is necessary to identify a relatively large area; a large number of measurements are made, where the end result is the average of all measurements. It is equally essential that the procedures adopted are clearly explained in the "file" handed to the next person carrying out the analyses.

It is important to bear in mind that these measurements are subject to many factors influencing their repeatability. Painting surfaces are never perfectly smooth, thus influencing the support and contact, which need to be very delicate. Additionally, each operator's hand is different, causing slight discrepancies in the measurements.. As the measurements are usually done by two people (one plotting the areas measured and the other doing the measuring), it is good practice to repeat one in every five measurements inverting roles, to check their repeatability. The data should also be supplied in the "file" so that anyone reading the measurements has an idea of their reliability.

Usually each single measurement consists in several "shots" carried out on the same point so the instrument is able to supply the standard deviation of the measurements carried out.

## 4. Examples cases

Here are examples of two very different cases:The first (figure 1) is a painting where, because of the thin brush strokes, it was not possible to pinpoint spots of a size larger than 2 mm. Precision in identifying the point was crucial. Every measurement was carried out by way of 9 shots.

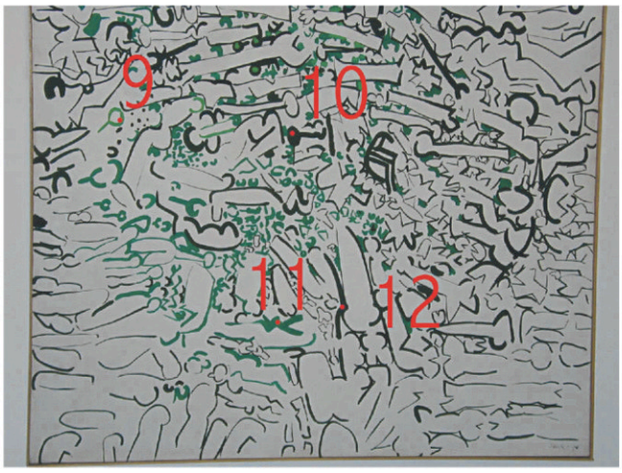


**Figure 1 Antonio Sanfilippo – Fir Green. (The measurements made on the occasion of an exhibition on the "Formal" group and its artists and at the request of Professor Simonetta Lux, the curator of the exhibition, and under suggestion of Professor Giuseppe Basile of ICR in Rome). The measuring points were the smallest possible, given the instrument spot (2 mm.)**

This type of measurement occur often [4].

The second example (figure 2) is taken from old Japanese photographs typical of the so-called "Yokohama School": the albumen prints from the Meiji era (1860-1910) are finely coloured by hand, for the most part by local artists, the same who devoted their efforts to colouring fabrics and prints. The colour is considered an added value as it is the unique characteristic of Yokohama School photographs compared to all the others produced at the end of the 19th century. The works concerned are part of a private collection recently purchased by the "Ada Ceschin Pilone Foundation" of Zurich, which has lent these permanently to the Lugano "Delle Culture" Museum.

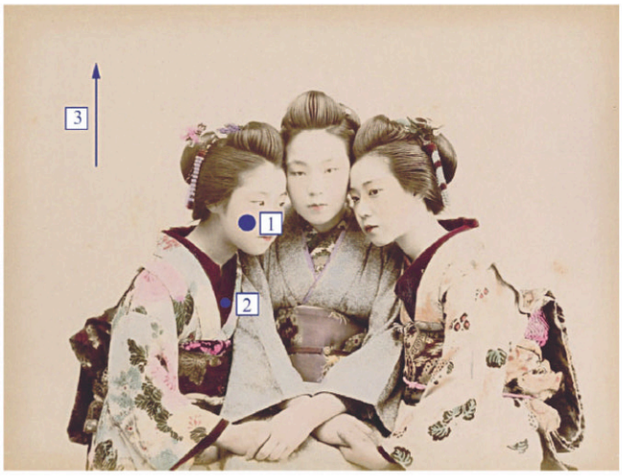


**Figure 2 Three young "maikos" (image 10 Catalogue 31), Kusakabe Kimbei, 1890 ca. The measuring points 1 and 2 have sufficiently large areas to enable measurements with several shots to obtain results. Point 3 is an example of monochrome background and was measured with a line of 12 adjoining measuring points, as indicated by the arrow**

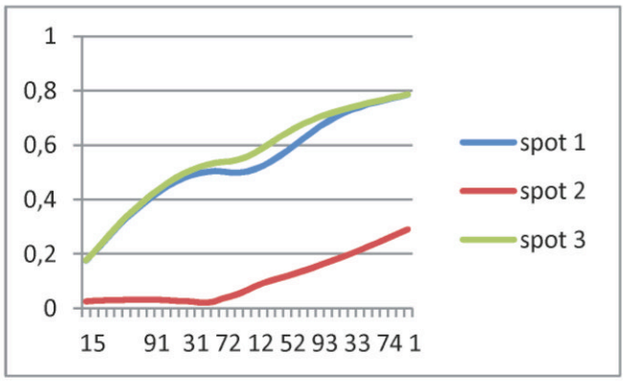


**Figure 3 Reflectance curves. The reflectance factor for the 3 different spots vs. wavelength (1=380, 41=780 nm.)**

The following table shows the relative colorimetric data in the two most used colour spaces:

| | Y | x | y | L* | a* | b* |
|---|---|---|---|---|---|---|
| Spot 1 | 50.14 | 0.342 | 0.362 | 75.16 | - 0.43 | 13.63 |
| Spot 2 | 5.07 | 0.443 | 0.335 | 26.92 | 21.58 | 11.05 |
| Spot 3 | 53.97 | 0.35 | 0.365 | 78.44 | 1.35 | 16.52 |

## 5. Double utilisation

As mentioned the colorimetric data is very important for monitoring the painting's decay. The procedure is easy: repeat the measurements in the same points after a certain amount of time. The colours of a painting change, sometimes swiftly, sometimes after long periods of time. A radical example of this took place in Ercolano during a volcanic eruption (Figure 4). It is well known that in the Vesuvian area stand pieces of wall plastered and painted with yellow ochre that turned to red as a result of the high temperature brought about by the volcanic eruption [5].The roasting and red-heating process was well-known to the Romans, who already obtained "usta" (our minium), which is a red derived from lead, by heating "cerussa" (our ceruse), which is a white lead. This technique, described by Pliny, dates back to Vitruvius and even Theophrastus.

**Figure 4 Change in colour caused by the temperature of the gas that seeped through the crack in the wall We do not know and we shall never know the exact original shade of yellow of the painting but we can check if the colour is slowly changing. This is possible by taking colorimetric measurements at regular time intervals over many years.**

This procedure is adoptable for any painted surface [6]. In the example of the figure 5 the indicated areas were considered as backgrounds.

**Figure 5 Cerveteri. The Etruscan "Dei Rilievi" tomb (IV cen. B.C.). Yellow and red area measurements.**

## 6. Conclusions

It is important to stress that this technique is economical, not invasive and extremely quick; about twenty different measuring points, which constitute a reasonable average for a painting of about 1 $m^2$, can be surveyed and recorded in about one hour. Moreover, once valid operating instructions have been drawn up, non-specialised personnel can also perform the tests.

For this kind of file high resolution is not necessary, even a low resolution in black and white can be acceptable, provided that it is enough to give a precise indication of the points where the measurements have been carried out. Naturally the list of these measurements should not be considered a complete catalogue card, but rather a sub-card or, better still, one of the various measurements necessary for compiling a complete catalogue card.

The data acquired can, of course, also be used for colour calibration should reproductions be needed.

I find it necessary to point this out as I have noticed that often in many fields problems arise between those responsible for putting the research and/or technique together and its final users In this case, problems may arise between those involved in technological research in artistic heritage working in the pursuit of knowledge, and final users wishing to preserve and enjoy art. In order to define the methodology and/or draw up a list of instructions, it is necessary to involve curators and art historians for the following reasons., The first reason, as I mentioned earlier, is that they play an important part as the final users of this technique . The second reason is because of the knowledge and experience they can provide to build the methodology. The procedure, in the sense of technical norms is, and will be ever more, put together and defined by technical personnel but what is perhaps lacking is guidelines about what to in fact measure, or rather, looking at a painting in the usual way/considering a typical painting, which points or areas need to be taken into account for its memorisation for the future. Put simply, what and in what way it would be useful to record. Clearly the question, when looked at in

its entirety, is extremely complex, given that, for example, it should not neglect the aspect of the materials used in the point measured - with one pigment deteriorating differently from another and so on – but nevertheless, even if the artist conceived the work in question in terms of "non-immobility of materials", the memorisation of the starting point is important, at the very least as documentation.

## 7. References

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