

**NPL REPORT
DQL-OR 005**

**The Uncertainty of Surface
Colour Measurements made
with Commercially Available
Instrumentation and
Recommended Calibration
Protocols**

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Quality of Life Division

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The uncertainty of surface colour measurements made with commercially-available diode-array instrumentation and recommended calibration protocols.

1 ABSTRACT

This work was carried out as part of the DTI NMSPU funded Optical Radiation Measurement Programme within the Optical Programme.

The overall purpose of the project is to demonstrate what level of uncertainty one might expect to achieve in the measurement of reflected colour using a diode-array spectrophotometer, and how one might assess it. In addition, a suitable protocol is to be developed to reduce this uncertainty.

Five instruments were investigated, one instrument had several measurement parameters: the area measured (adapted using a series of different sized measurement apertures), and the geometry used – with the specular component included or excluded.

Samples tested were Ceramic Colour Standards, (two sets of 12 with matt and glossy finishes respectively), plus black, white and 50% grey tiles each with glossy and matt surfaces.

‘Instrument out of the box’ values were initially obtained, with only thermochromic corrections applied, and compared with results of the same tiles as measured using an NPL calibrated high quality scanning spectrophotometer.

Alterations to the tile values were then made to account for photometric scale and linearity.

A series of 15 repeat measurements was used to investigate repeatability.

The data from these measurements were combined in a novel fashion to provide a wavelength variant measurement uncertainty for each instrument before and after corrections were applied.

Most of the values discussed in the report are colorimetric, spectral data are represented visually in the appendix.

2 SCOPE

The objectives of this report are:

1. To investigate the level of uncertainty afforded by diode-array instrumentation in measurement of reflected colour;
2. to establish a calibration protocol for these instruments using a small set of calibrated artefacts and software;
3. to use the results from this investigation to illustrate important aspects of traceability and uncertainty.

3 DIODE-ARRAY TECHNOLOGY OVERVIEW

3.1 *Origins of uncertainty in diode-array spectrophotometer measurements.*

3.1.2 Source and source stability

The function of diode-array spectrophotometers is described in detail elsewhere [1]. The light source typically, but not exclusively used in these instruments is a xenon flash-lamp. To account for variations in the intensity and relative spectral power in the lamp, signals from two detector arrays are often compared – one effectively monitors the source directly, and the second detects light reflected (or transmitted) by a sample. In both cases, light is diffracted onto the detector array by a fixed grating. There are few moving parts, (occasionally a shutter or port caps), and measurements are fast in comparison with more historic wavelength-scanning systems. As the statistical nature of light limits the accuracy with which it can be measured (to be described later), the best solution is to illuminate and collect light as intensively as possible. The limitations on illumination level are power, safety and damage to sample considerations. The amount of light collected is limited by the measurement geometry, which is often determined by international agreed convention.

For samples that fluoresce, the actual light source will have a bearing on results. Whilst some instruments provide an option to include or exclude UV radiation, this will remain an issue for samples which are excited by higher wavelengths. Since the full nature of incident radiation is not accounted for, the systems are incapable of comprehensively measuring fluorescent samples.

3.1.3 Bandwidth

The effective bandwidth of the diode-array system is complex and comprises several stages. Initial optical bandwidth is determined by a physical slit in front of the grating. The engineering challenge here is to use a sufficiently narrow slit to achieve good spectral resolution, whilst keeping it broad enough to enable a suitably high signal-to-noise ratio. A typical slit might provide a triangular bandpass function with a full width-half height of 8 nm.

The diode-array will contain typically 1024 elements which are grouped together in ‘reporting bins’, determined in part by the geometry and wavelength range. For many current instruments this interval is 4.88 nm. Data collected in these bins must then be integrated with the CIE Standard Observer colour matching functions published at 1 nm intervals. How exactly interpolations and convolutions occur in the integration process will potentially affect the final result.

The overall effective bandwidth of diode-array systems is a difficult quantity to appraise because manufacturers are reticent to provide details on instrumental hardware and software. Initially, an evaluation of bandwidth might seem simple to achieve, but monochromatically reflecting or transmitting media do not exist, (dielectrics with spectrally narrow properties are geometry sensitive and spectrophotometers measure light reflecting from ranges of angles). In addition, sloped spectral media such as cut-on and cut-off filters give only very limited, and complex to evaluate results, and the routine operation of these devices will not permit the simple inclusion of narrow bandwidth sources such as lasers in the optical path.

At this time, although NPL has recently re-evaluated the situation, there is no method for investigating bandwidth and its impact on errors and uncertainties in diode-array spectrophotometers.

3.1.4 Wavelength Range

Colorimetry is based on colour matching functions published by the CIE [2] over the wavelength range 380 to 780 nm. Few diode-array systems generate results over this full range – for example operating instead from 350 to 750 nm. Excluding some wavelength data points from colorimetric calculation may introduce a significant error in some cases.

3.1.5 Light collection

How the light is collected from the reflecting sample is a critical aspect of colour measurement. The CIE stipulates several measurement geometries with associated tolerances [2], which are implemented in measurement hardware with a range of proficiencies. As a result, a single sample may yield results which vary from one instrument to another. It is for this reason that matt transfer standards were developed by NPL, to reduce the errors which were occurring as a result of measuring matt samples in an instrument whose scale has been calibrated using a glossy standard. This issue is common to all colour measurement instrumentation – not just diode-array systems. It is however, a significant factor and an evaluation of how specularly reflected light is dealt with in a measurement is important.

3.1.6 Light detection

As mentioned previously, light level limits the performance (signal-to-noise ratio) of optical systems.

Photons incident on the detector diode-array are converted to photoelectrons constituting the signal. There are statistical fluctuations in the photon arrival rate at a given point in a process called photon noise which follows Poisson statistics giving a square root relationship between signal and noise.

The detector itself will spontaneously generate a ‘dark current’ of electrons that are indistinct from photoelectrons. Finally, ‘read noise’ originates in the on-chip amplifier which quantifies the electronic signal on the diode-array. Combining all these elements, signal and noise for a diode-array detection device is given in Table 3.1.

Table 3.1: Comparison of signal with noise for diode-array based detection system

Signal	$IQE t$
Noise	$\sqrt{(IQE t + Nd t + Nr^2)}$

where:

I = Photon flux (photons/pixel/second); QE = Quantum efficiency;
 t = Integration time (seconds); Nd = Dark Current (electrons/pixel/sec);
 Nr = Read noise (electrons RMS/pixel).

3.2 A note on ‘calibration’ of instrumentation.

Many diode-array spectrophotometers will refuse to measure until a ‘calibration procedure’ has been implemented. It is important to stress that whilst this procedure usually involves a calibrated artifact, it is not necessarily a calibration in the true sense of the word. Calibration

is the ascription of a scale to an instrument by direct comparison between subsequent measurement results and those of an artifact of ‘known’ value (where ‘known’ implies that the value of the artifact is traceable to a national scale). What is more likely to be happening is a characterization – whereby a calibrated artifact is measured by the instrument at start-up, and if the values determined by the system do not differ from those expected, within a given tolerance, the system will pass and be available for subsequent use. This method does not correct values according to results of this initial measurement, and what is highly relevant is the width of the given tolerance.

3.3 Repeatability, Agreement, Uncertainty and accuracy.

Diode-array spectrophotometers can give highly repeatable measurements – an aspect much promoted by manufacturers. Whilst this may be all that is required to check for stability or conformity in a production line environment, an instrument repeatedly producing the WRONG measurement will cause problems if results are to be used elsewhere, or it is required to evaluate samples to an external specification. It is unfortunate that discussions with some users of instruments revealed that the repeatability is often taken to equate to overall accuracy.

Agreement between instruments of the same model – so-called ‘inter-instrument agreement’ - is another figure of merit stressed by manufacturers. Again, this is of limited value. Any given model will have its own specific ‘systematic’ errors which may only become apparent when results of a set of samples measured on several instruments of different type do not agree. There are occasions when this is not an issue – for example if a test-house commits to using solely one model. This figure of merit is, however, irrelevant if results are to be exported outside the immediate application, or results are required to comply with a specification of external origin based on results from a different model of instrument.

The overall accuracy of an instrument is probably best gauged by the metric of ‘measurement uncertainty’ which is defined [3] as a:

“Parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand.”

The uncertainty of a measurement comprises several elements which can be determined experimentally. One such element derives from repeatability, which indicates the statistical ‘noise’ of the measurement.

3.4 Error

In a similar way to the evaluation of uncertainty, error may be evaluated by experimental means. The difference between the two quantities is that part of the error that may be corrected for. The tools used in evaluating uncertainty and error will themselves contain an associated uncertainty which must be added to the overall uncertainty budget.

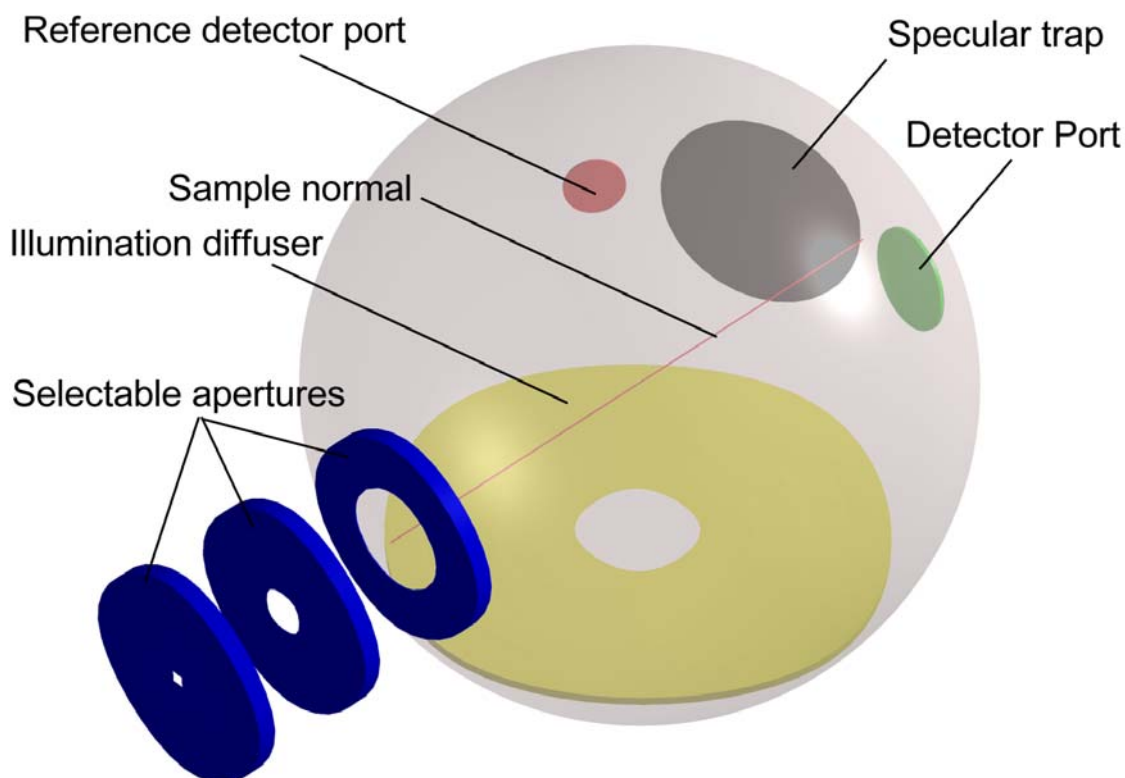
4 INSTRUMENTATION EVALUATED

For commercial reasons, the identities of the instruments investigated in this report are not given. The instruments tested use technology that typifies both reasonable quality mid-priced instruments and lower priced handheld instruments, at the time of the investigation.

4.1 Instrument 1

The integrating sphere of this instrument is illustrated in Figure 4.1

Figure 4.1: Diagram of integrating sphere for instrument 1.



The integrating sphere is 150 mm in diameter and is coated with barium sulphate paint. Diffuse illumination originates from a xenon flash lamp passed through a D65 ‘conversion’ filter, entering the sphere (at the south pole) via a circular translucent diffusing element 120 mm in diameter constituting approximately 20% of the total sphere wall area and shown in yellow in the figure. The diffuser prevents light from the source shining directly onto the sample or through the detector port. The short pulse nature of the source minimises sample heating effects.

The sample port is located at 90° to the source port (this angle is referred to the sphere centre), and has a diameter of 50 mm. This area can be stopped down with a series of interchangeable apertures shown in blue. The stops used in this investigation were as given in Table 4.1.

Table 4.1: Apertures of instrument 1

Name given	Diameter /mm	Diameter /% of total sphere area
Large	25	4.2
Medium	10	1.7
Small	3	0.5

The port reducing apertures have a reasonable knife-edge. They have a metallic shiny finish so in terms of reflectance are not perfectly continuous with the rest of the sphere.

A multi-diode-array detector views the sample and sphere through a 25 mm diameter port (marked in green) centred 4° from the normal to the sample (i.e. almost opposite the sample port).

A second detector port of 15 mm diameter (marked in red) is located 26° to the sample normal. Readings from both detectors are compared and used to account for variations in intensity and relative spectral power of each illumination flash.

A portion of the sphere wall 50 mm diameter (marked in grey), centred at 10.5° from the sample normal may be included or excluded to permit the use of specular included or excluded geometries respectively.

Diode-array instruments gather spectral information into discrete bands – in this instance at 10 nm intervals from 350 to 750 nm.

The software requires ‘calibration’ to take place after switch-on of the instrument. This uses a white tile and a black glass trap. It is essentially an instrumental stability evaluation – as described above, the scale itself is not adjusted. Instead, a comparison is made with the expected result and if values are outside an associated tolerance, the software will refuse to proceed with measurements.

4.2 Instrument 2

In many respects this instrument is similar to instrument 1 other than in terms of its measurement geometry, which is not sphere-based but achieves a 45/0 geometry using a ring collector.

Illumination is provided by a pulsed Xenon source monitored by a detector to account for changes in absolute and relative spectral level between flashes. Using a series of mirrors, the last of which is an annular ring, light illuminates the sample at $45^\circ \pm 10^\circ$ (this tolerance is estimated). The sample is held against a 16 mm circular aperture, of which the central 14 mm is illuminated. Light is collected via a lens and mirrors system from an area of diameter 10 mm centred on the sample.

Spectral data are generated at 10 nm intervals from 380 to 750 nm with 14 bit photometric resolution.

A calibration routine employed following switch on of the instrument uses a white tile. It is not known how this procedure affects results.

4.3 Instrument 3

This instrument uses a tungsten-halogen lamp with a colour temperature of approximately 4000 °K to illuminate a sample area of 12 mm diameter at 45° . Fixed reflectance

measurement points are located at aspecular angles of 15°, 25°, 45°, 75° and 110°[#]. The quoted accuracy on these angles is $\pm 0.15^\circ$. From these points, a fibre-optic bundle conveys light to a set of 'blue-enhanced' silicon photodiodes. The 'spectral resolution' (taken to mean spectral bandwidth) of the instrument is 10 nm from 400 to 640 nm, then 15 nm from 640 to 700 nm. Measurement time is about 2 seconds. The instrument exports values (which are interpolated to 10 nm interval data from 400 to 700 nm) via an RS232 link.

For calibration, (done as required), a white tile is used to monitor the measurement scale. If there are significant changes since the last calibration, additional measurement of a black gloss trap to set dark level is requested. Only the data measured using illumination at 45° and detection at 0° (45° aspecular) are considered in this report.

4.4 Instrument 4

The geometry of this instrument is similar to that of instrument 2. Illumination from a pulsed Xenon gas discharge tube is conveyed to the sample surface via an annular reflector at 45°. The illuminated aperture is set to 5.5 x 6 mm. Reference measurements are made of the light output, voltage and temperature to account for changes between source flashes. The detected area is 1.5 x 2 mm at an angle of $0^\circ \pm 5^\circ$.

During the course of about 0.4 seconds, 15 readings are taken (the source flash frequency being 35 Hz), and the mean of these measurements provides the result.

Results are obtained from the array detector at approximately 4 nm intervals from 350 to 812 nm with 12 bit photometric precision and require interpolation to obtain data at other intervals.

The instrumental wavelength accuracy is given as 2 nm. The instrument requires calibration each time it is switched on. This uses a white plaque traceable to the European Community Bureau of Reference.

4.5 Instrument 5

For this 45/0 geometry instrument, illumination is provided by an unspecified light source at 45°. Detection of an area of 4 mm diameter (or 3 mm depending which manual is read) is made at 0° with results reported at 10 nm intervals from 380 to 760 nm. The instrument is described as having a 'resolution' of 9 nm, which is taken to indicate bandwidth.

Measurement time is typically 150 ms. It is recommended that the unit is recalibrated at least daily using a white plaque traceable to BAM (Germany).

4.6 Summary of instrument features

Instrument	1	2	3	4	5
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[#] Aspecular angles are those measured with respect to the specular angle. Thus, with illumination at -45°, the aspecular angle is at 45°. Measurement at an angle of 45°, with respect to the aspecular angle, corresponds to a measurement geometry of 45°/0°.

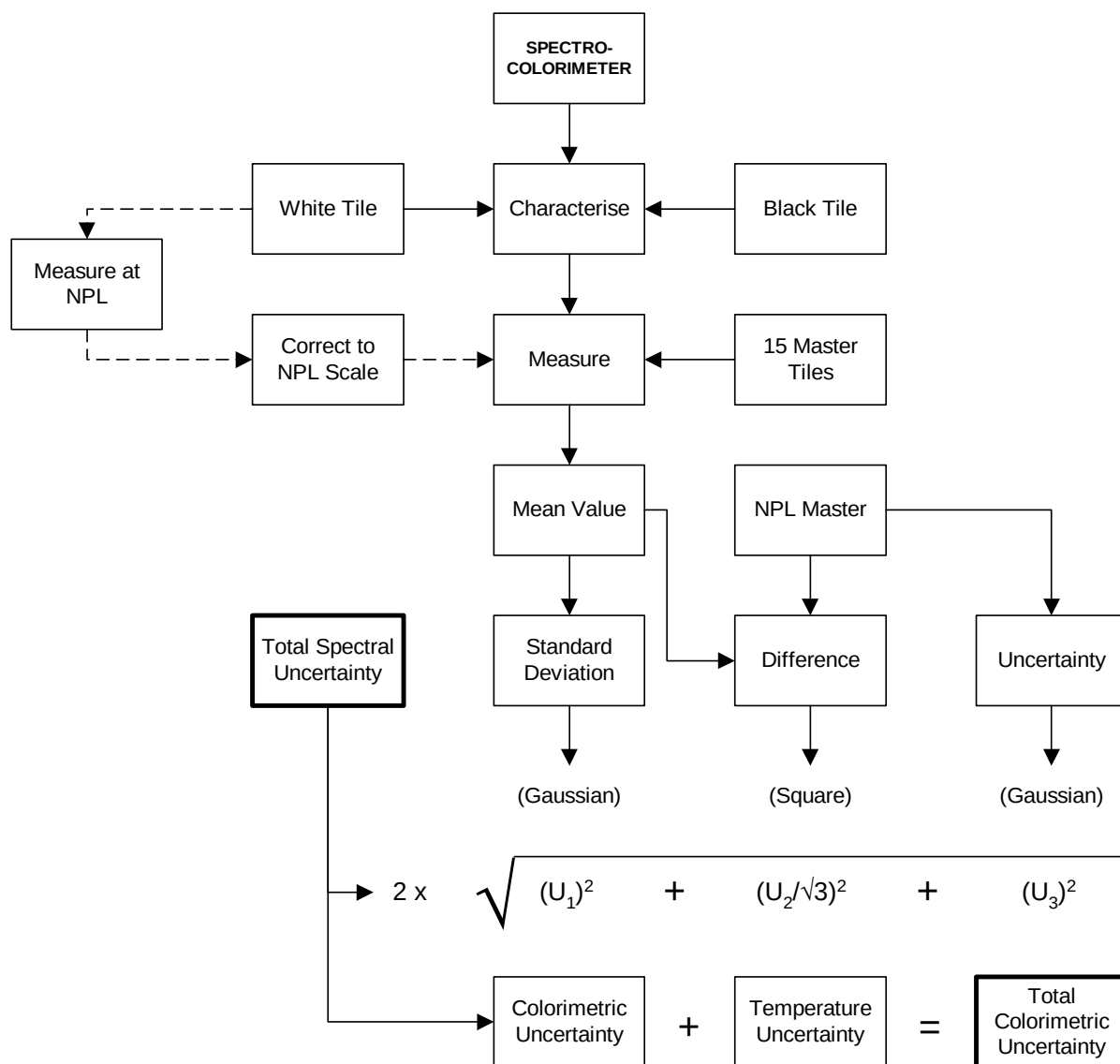
Wavelength range and interval /nm	350/10/750	380/10/750	400/10/700	380/5/760	380/10/760
Bandwidth /nm	Not known	Not known	10-15	20	9
Geometry	Diffuse/4 or total/4	45/0	45/ (15, 25, 45, 75, 110)	45/0	45/0
Measurement area /mm	Ø=25, 10, 3	Ill Ø=14 Detect Ø=10	12	Ill=53.5x4 or 55x6 Detect=1.5x2	4
Measurement time /s	1	Not known	2	0.4	0.15
light source	Xenon flash	Pulsed Xenon	Tungsten Halogen 4000 K	Pulsed Xenon	Not known

Rather than use the instrumental colorimetric evaluation software, a common routine was employed using the spectral data. For this, the spectral range and interval of data were standardised to 350/5/700 nm. A Lagrange interpolation routine was used to convert data at 10 nm intervals to 5 nm intervals if required.

5 MEASUREMENT AND ANALYSIS

5.1 Overall measurement strategy.

The general procedure developed to ascertain the measurement uncertainty of a spectrophotometer is given in Figure 5.1.

Figure 5.1: Block diagram showing the steps in the characterisation procedure.

The experimental method of this investigation was to measure a range of neutral and coloured ceramic tiles on several diode-array spectrophotometers. As described above, most of the instruments were capable of more than one measurement geometry, and a statistical analysis of the results from each geometry was made using sets of 15 repeat measurements of each tile. The standard deviation of the results from the 15 measurements indicated individual instrument repeatability. The difference of the mean of these values from the ‘true’ value of the tiles as established by direct comparison of the tiles against master reference tiles (traceable to the national diffuse reflectance scale) on scanning spectrophotometers at NPL.

To enable cross-referencing between different stages of the analysis process, subsequent paragraphs in this section have been numbered.

5.2 Measurement

1. The instrument was switched on and allowed to stabilise for at least 30 minutes in the laboratory.
2. The required set of master tiles was also placed in the laboratory and allowed to stabilise to the laboratory temperature. The approximate laboratory temperature was 23 °C. Each set of master tiles comprised 15 artifacts: a set of 12 Glossy Ceramic Colour Standards – Series II plus a White, Black, and 50% Grey glossy tile, or a set of 12 Matt Ceramic Colour Standards plus the appropriate White, Black, and 50% Grey matt tiles. The master tiles sets used for this analysis, selected according to the geometry of the instrument, are those designated in Table 5.1

Table 5.1: Master tile sets used for the measurements

	Glossy	Matt	Glossy	Matt
	d/8	d/8	45/0	45/0
Colour	Set ½	CCM6	CCS3	CCM6
White	WT53	WT45	WT56	WT45
Black	BT03	BT10	BT03	BT10
50% Grey	GT51	GT41	GT51	GT41

3. If appropriate, instrument parameters were set, e.g. aperture size, geometry – specular component of reflection included (SPIN) or excluded (SPEX), UV component – included or excluded, wavelength range and wavelength interval. It was intended that all of the analyses be carried out using data at 5 nm intervals. If this were not available from the instrument software, then the actual measured data would be interpolated to give data at 5 nm intervals. The ideal wavelength range was considered to be 380 nm to 780 nm. If this range were not available then the data within the actual range measured by the instrument were used.
4. The instrument was characterised. In all cases, this involved measuring a white tile; in some cases a black tile or light trap was also measured. It is assumed that the instrument software compared the measured spectral values with those in a stored table and, if there were a significant difference in any value, would flag the operator.
5. Each of the 15 tiles in the appropriate set was measured 15 times. This was usually done in sets of three, thus tiles 1, 2 and 3 would be measured in this order and then the same order repeated 14 more times. Then, the same was done with tiles 4, 5, and 6 and so on until all 15 tiles were measured 15 times. There was no instrument re-characterisation between measurements, and the tile was removed from the instrument between each measurement. Care was taken to ensure that the same part of the tile, the centre, was measured each time, although it is recognised that some variation in the measurements may be due to this goal not being achieved.
6. The measured spectral data were stored, either as ASCII files or in a bespoke format specific to a particular instrument. To facilitate analysis, these latter data files were translated to a common ASCII format. All of the ASCII files were then imported into a spreadsheet.

5.3 Analysis of Spectral Data

The following calculations were then made based on the spectral data and using the approach given in Figure 5.1.

7. If required, data were interpolated to have 5 nm intervals. A Lagrange interpolation formula was used based on the two adjacent pairs of values above and below the required wavelength:

$$\begin{aligned}
 R = & R_1(\lambda - \lambda_2)(\lambda - \lambda_3)(\lambda - \lambda_4) / (\lambda_1 - \lambda_2)(\lambda_1 - \lambda_3)(\lambda_1 - \lambda_4) \\
 & + R_2(\lambda - \lambda_1)(\lambda - \lambda_3)(\lambda - \lambda_4) / (\lambda_2 - \lambda_1)(\lambda_2 - \lambda_3)(\lambda_2 - \lambda_4) \\
 & + R_3(\lambda - \lambda_1)(\lambda - \lambda_2)(\lambda - \lambda_4) / (\lambda_3 - \lambda_1)(\lambda_3 - \lambda_2)(\lambda_3 - \lambda_4) \\
 & + R_4(\lambda - \lambda_1)(\lambda - \lambda_2)(\lambda - \lambda_3) / (\lambda_4 - \lambda_1)(\lambda_4 - \lambda_2)(\lambda_4 - \lambda_3)
 \end{aligned}$$

where R is the estimated value of spectral reflectance at wavelength λ and the known values of the spectral reflectance are designated R_1, R_2, R_3, R_4 at wavelengths $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ respectively.

8. The whole analysis procedure outlined below was carried out twice. The first set of calculations, designated as using ‘uncorrected’ data, continues at (9) below.

9. In order to calculate ‘corrected’ data, the following additional step was inserted. The spectral reflectance, $R_{\text{Lambda}, \lambda}$, of the white characterisation plaque supplied with the instrument was measured on the NPL Perkin Elmer Lambda 19 master instrument using the usual NPL procedure and with the instrument set at the appropriate geometry. This gave a measure of the tile using the NPL reflectance scale. This tile was also measured 15 times on the instrument being assessed and a mean value, $R_{\text{Instrument}, \lambda}$, calculated. All of the measured data from (7) above were then corrected to the NPL reflectance scale by multiplying the individual reflectance data by a factor equal to $R_{\text{Lambda}, \lambda} / R_{\text{Instrument}, \lambda}$. These steps are shown by the dotted line in Figure 5.1 above.

10. The average of the 15 measurements of each tile was calculated at each wavelength. This gave the average data for each ceramic tile.

11. The value of the standard deviation associated with the above average was calculated at each wavelength. This gave a measure of the repeatability of the data for each ceramic tile.

12. The NPL master spectral data were then subtracted from the average data from (9) above. This difference in spectral data gave a measure of the accuracy of the data.

12. The uncertainties in the spectral data were calculated according to the following formula:

$$U_{s, \lambda} = k \sqrt{(U_1)^2 + (U_1 / \sqrt{3})^2 + (U_3)^2}$$

where: $U_{s, \lambda}$ is the total spectral uncertainty at wavelength λ .

U_1 is the contribution to this uncertainty due to the variance in the repeatability of the measurements – calculated in (10) above. This has a Gaussian distribution.

U_2 is the contribution to the uncertainty due to the difference between the average of the measured data and the NPL master data – calculated in (11) above. This has a rectangular distribution and is hence divided by a factor of $\sqrt{3}$.

U_3 is the contribution to the uncertainty due to the uncertainty in the NPL master data. This has a Gaussian distribution.

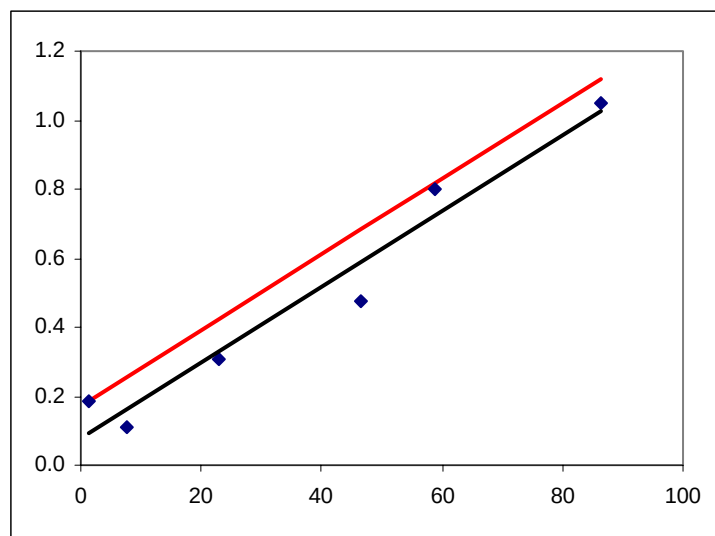
k is the covering power. This has a value of 2 to provide a level of confidence in the uncertainty of approximately 95%.

Note: Where the values of U_1 and U_3 are quoted with a covering power of 2, corresponding to 95% confidence, they have been pre-divided by a factor of 2 before performing this final calculation.

5.4 Analysis of Linearity

13. Data for the neutral tiles were selected. There are 6 of these tiles: the pale grey, mid grey and deep grey from the set of 12 tiles and the additional black, white and 50% grey tiles. The value of spectral uncertainty was plotted as a function of the associated value of spectral reflectance for data at 400 nm - 700 nm in steps of 50 nm – 7 graphs. An example graph is shown in Figure 5.1.

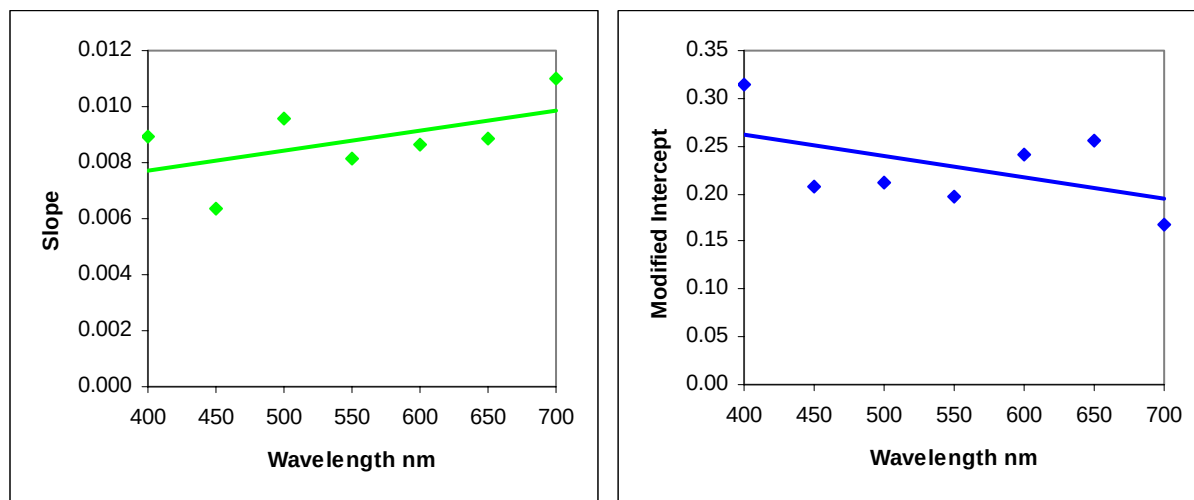
Figure 5.1: An example of uncertainty in reflectance plotted as a function of reflectance.



14. A least-squares analysis was used to find the best-fit line through the 6 data points – shown by the black line in Figure 5.1. The intercept of this line was then increased such that the line sat through the point that deviated most from the least-squares line – the red line in Figure 5.1. This procedure was repeated for all 7 sets of data.

15. The values of slope and modified intercept for each of the 7 wavelengths were then plotted as a function of the wavelength, Figure 5.2.

Figure 5.2: The value of the slope (left) and modified intercept (right) of the least-squares line relating the uncertainty to the spectral value, plotted as a function of wavelength.



16. The uncertainty was assigned according to the maximum value of slope and intercept in two spectral ranges. Experience at NPL suggests that two spectral ranges are necessary in order not to assign too high an uncertainty to data measured at wavelengths > 460 nm.

The following values would be assigned from the data plotted in Figure 5.3:

≤ 460 nm Uncertainty = 0.009 R% + 0.320

≥ 465 nm Uncertainty = 0.011 R% + 0.260

Figure 5.3: Uncertainty profile for a reflectance of 100%

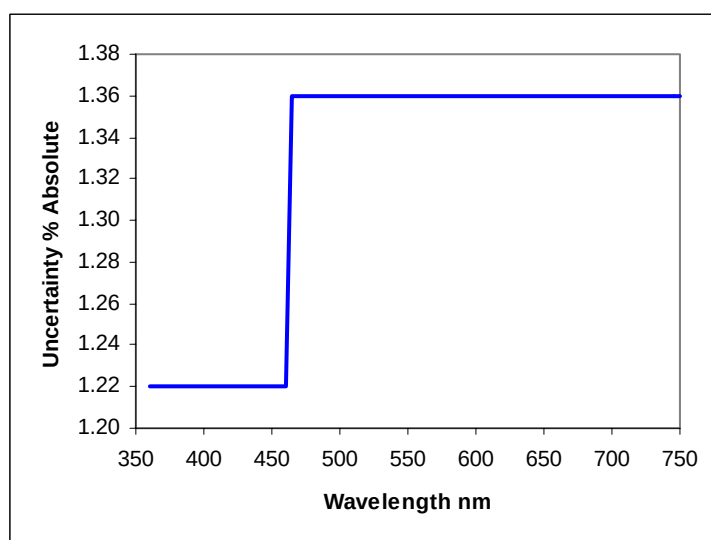


Figure 5.3 shows the uncertainty profile associated with wavelength as a function reflectance. For the purposes of this calculation, the value of reflectance has been set at 100%.

5.5 Analysis of Colorimetric Uncertainty

17. Colorimetric coordinates (X , Y , Z , x , y , L^* , a^* , b^*) were calculated from the average spectral data (calculated in (9) above), the average data + the spectral uncertainty defined in (16) above, and the average data – the spectral uncertainty defined in (16) above.

18. Differences were then calculated between the colorimetric coordinates associated with the average data and those associated with the data $\pm$ the spectral uncertainty. The larger of these two values, in an absolute sense, was taken as the uncertainty to be associated with the respective colorimetric values.

19. These values of uncertainty were increased by including a measure of the possible effect due to temperature. Data are available that correspond to a 10 °C change in temperature. These values are divided by five to give the equivalent data for a 2 °C change in temperature and added in quadrature to the uncertainty values calculated in (18) above.

20. The median and maximum values of the colorimetric uncertainties were calculated over all 15 tiles in the measured set. The median is the best measure of central tendency for the distribution of values of uncertainty which are unlikely to be normally distributed. The maximum value was quoted to give an indication of the range of values obtained.

5.6 Results Outputted

21. In the Appendix, eight pages of tables and graphs are given for each instrument configuration and tile finish as detailed below:

	Section above:
Page 1	Details of instrument parameters.
	List of tile sets measured. (2)
	Values for the spectral uncertainties as a function of wavelength before and after scale correction: 400 – 700 x 50 nm. (14)
	Parameters for the spectral uncertainty profile. (16)
	Median and maximum values of the colorimetric uncertainties calculated using spectral data before and after scale correction. (20)
Page 2	Colorimetric uncertainty values – uncorrected scale – with temperature correction – for all 15 tiles measured. (19)
	Colorimetric uncertainty values – corrected scale – with temperature correction – for all 15 tiles measured.
	Colorimetric uncertainty values for the NPL Master data.
Page 3	CIELAB L^* , a^* , b^* data for the 15 tiles – first measurement. (A)

CIELAB L^*, a^*, b^* data for the 15 tiles – average of 15 measurements – uncorrected data. (B)

CIELAB L^*, a^*, b^* data for the 15 tiles – average of 15 measurements - corrected data. (C)

CIELAB L^*, a^*, b^* data for the 15 NPL Master Tiles. (D)

CIELAB colour difference, ΔE_{ab}^* , A to B

CIELAB colour difference, ΔE_{ab}^* , B to C

CIELAB colour difference, ΔE_{ab}^* , B to D

CIELAB colour difference, ΔE_{ab}^* , C to D

CIELAB L^*, a^*, b^* data for the 15 tiles + uncertainty. (E)

CIELAB L^*, a^*, b^* data for the 15 tiles – uncertainty. (F)

Page 4 Bar charts showing the values of uncertainty for each of the 15 tiles: uncorrected data (pink), corrected data (blue), NPL master data (maroon).

Top: L^* , Middle: a^* , Bottom: b^*

Page 5 Bar charts showing the values of $\pm$ the uncertainty for each of the 15 tiles – Left: NPL master data, Right: Corrected data subtracted from the NPL master data, with $\pm$ the calculated uncertainty.

Top: L^* , Middle: a^* , Bottom: b^*

Page 6 Left: Spectral reflectance plotted as a function of wavelength: uncorrected data (green) – corrected data (blue) – NPL master data (green).

Right: Standard deviation of 15 measurements (magenta), NPL master data subtracted from the uncorrected data (red), NPL master data subtracted from the corrected data (blue).

Top: White tile, Middle: 50% Grey tile, Bottom: Black tile

Page 7 As Graph 3: Top: Red tile, Bottom: Cyan tile

Page 8 As Graph 3: Top: Blue tile, Bottom: Yellow tile

6 SUMMARY OF RESULTS

The results given in the appendix are summarised in Table 6-1 to Table 6-3 and graphically represented in Figure 6-1 to Figure 6-6 below.

Colorimetric values given are median and maximum differences in the measured values from the NPL calibrated values. Spectral uncertainty data are given in the form Uncertainty = multiplier x R% + offset. The multipliers and offsets are given for two wavelength ranges.

Table 6-1: Uncorrected scale

Measurement condition					Median			Maximum			Uncertainty in form $y=mR(\lambda)+c$			
Instrument	Aperture Large/Med/ Small	Geometry	Tile finish, Glossy/Matt	Section	L*	a*	b*	L*	a*	b*	≤ 460 m	≤ 460 c	> 460 m	> 460 c
1	L	IN	G	A1	0.42	0.09	0.10	0.74	0.24	0.38	0.008	0.250	0.009	0.200
1	M	IN	G	A2	1.61	0.19	0.10	2.53	0.95	1.68	0.065	0.020	0.065	0.010
1	S	IN	G	A3	1.44	0.27	0.35	2.85	1.26	1.79	0.020	0.600	0.025	0.800
1	L	EX	G	A4	0.52	0.11	0.17	2.34	2.95	3.10	0.009	0.300	0.010	2.500
1	M	EX	G	A5	0.39	0.07	0.06	0.89	1.05	0.80	0.013	0.090	0.011	0.090
1	S	EX	G	A6	3.04	0.20	0.12	7.76	8.13	7.71	0.080	0.700	0.080	0.800
1	L	IN	M	A7	0.48	0.12	0.10	0.75	0.31	0.47	0.012	0.100	0.010	0.250
1	M	IN	M	A8	0.96	0.15	0.15	2.02	0.82	1.00	0.011	0.750	0.010	0.750
1	S	IN	M	A9	1.07	0.30	0.42	2.34	1.27	1.98	0.008	0.400	0.009	0.900
1	L	EX	M	A10	0.44	0.09	0.04	0.64	0.23	0.30	0.012	0.110	0.010	0.200
1	M	EX	M	A11	1.96	0.18	0.26	2.49	0.58	0.68	0.070	0.400	0.060	0.400
1	S	EX	M	A12	2.99	0.15	0.29	3.92	1.00	1.60	0.070	0.800	0.070	1.100
2		45/0	G	A13	0.63	0.17	0.28	2.32	2.15	1.82	0.025	0.250	0.015	0.250
2		45/0	M	A14	0.89	0.32	0.80	1.36	0.83	1.39	0.025	0.900	0.020	0.400
3		45/0	G	A15	1.03	0.31	0.78	4.63	4.42	4.56	0.030	0.700	0.020	0.500
3		45/0	M	A16	1.50	0.15	0.29	3.23	1.36	1.85	0.012	1.000	0.018	1.100
4		45/0	G	A17	1.22	0.24	0.58	6.44	6.25	5.61	0.025	0.750	0.018	0.700
4		45/0	M	A18	1.84	0.15	0.21	3.77	1.40	2.00	0.024	1.100	0.026	1.200
5		45/0	G	A19	2.12	0.33	0.66	7.55	6.58	7.75	0.030	1.200	0.050	0.800
5		45/0	M	A20	2.01	0.63	1.91	3.24	2.29	3.77	0.030	2.500	0.040	1.000

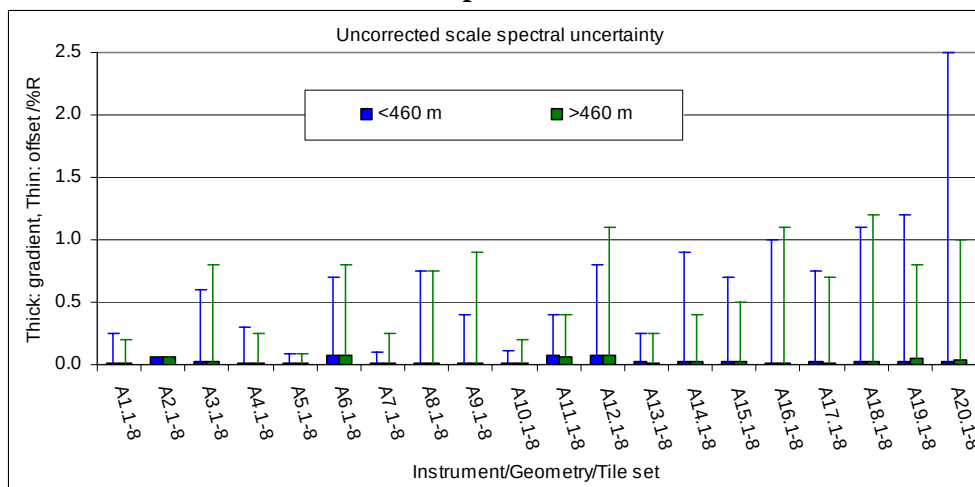
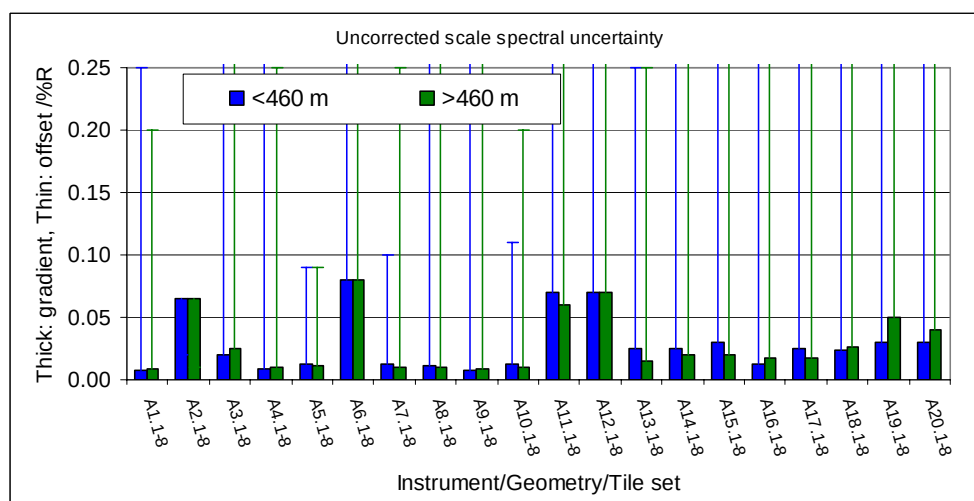
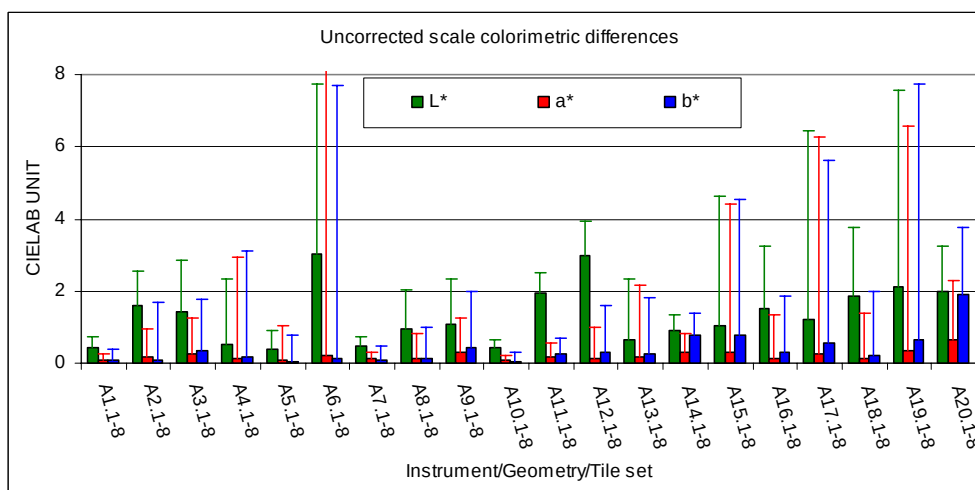
Figure 6-1: Uncorrected scale spectral uncertainties.**Thick bars are R multipliers, thin T's are R offsets.****Figure 6-1 rescaled to see detail****Figure 6-2: Uncorrected scale colorimetric differences.****Thick bars are median, thin T's are maximum.**

Table 6-2: Corrected scale

Measurement condition					Median			Maximum			Uncertainty in form $y=mR(\lambda)+c$			
Instrument	Aperture Large/Med/ Small	Geometry	Tile finish, Glossy/Matt	Section	L*	a*	b*	L*	a*	b*	≤ 460 m	≤ 460 c	> 460 m	> 460 c
1	L	IN	G	A1	0.31	0.12	0.08	0.70	0.33	0.39	0.006	0.200	0.004	0.210
1	M	IN	G	A2	1.56	0.79	1.36	2.29	1.73	2.31	0.006	0.030	0.060	0.000
1	S	IN	G	A3	1.22	0.24	0.26	2.72	1.27	1.77	0.014	0.600	0.016	0.800
1	L	EX	G	A4	0.38	0.10	0.09	2.02	2.78	2.33	0.005	0.220	0.005	0.220
1	M	EX	G	A5	0.38	0.10	0.09	2.02	2.79	2.32	0.005	0.220	0.005	0.220
1	S	EX	G	A6	2.75	0.17	0.17	7.67	7.83	7.98	0.070	0.800	0.070	0.800
1	L	IN	M	A7	0.28	0.04	0.08	0.43	0.19	0.24	0.008	0.150	0.006	0.140
1	M	IN	M	A8	1.15	0.16	0.24	2.65	1.18	1.46	0.008	1.000	0.008	1.000
1	S	IN	M	A9	0.85	0.35	0.35	2.01	1.14	1.64	0.005	0.400	0.004	0.800
1	L	EX	M	A10	0.29	0.09	0.12	0.46	0.18	0.32	0.005	0.250	0.006	0.150
1	M	EX	M	A11	1.69	0.16	0.28	2.09	0.45	0.58	0.060	0.400	0.050	0.400
1	S	EX	M	A12	2.33	0.17	0.21	3.57	0.88	1.43	0.060	0.800	0.050	1.100
2		45/0	G	A13	0.46	0.34	0.70	1.87	1.05	2.53	0.025	0.400	0.010	0.200
2		45/0	M	A14	0.71	0.15	0.40	1.24	0.39	0.84	0.016	0.600	0.013	0.400
3		45/0	G	A15	0.58	0.15	0.24	1.70	1.30	1.33	0.020	0.240	0.015	0.180
3		45/0	M	A16	1.05	0.19	0.49	2.09	0.65	1.33	0.020	0.900	0.015	0.700
4		45/0	G	A17	1.19	0.26	0.38	6.43	6.48	5.80	0.017	0.750	0.017	0.700
4		45/0	M	A18	1.81	0.14	0.30	3.75	1.37	1.86	0.019	1.200	0.025	1.200
5		45/0	G	A19	1.76	0.53	0.67	11.79	10.24	13.12	0.011	1.200	0.011	1.300
5		45/0	M	A20	3.02	0.16	0.61	7.38	3.30	4.24	0.015	2.500	0.020	2.500

Figure 6-3: Corrected scale spectral uncertainties.
Thick bars are R multipliers, thin T's are R offsets.

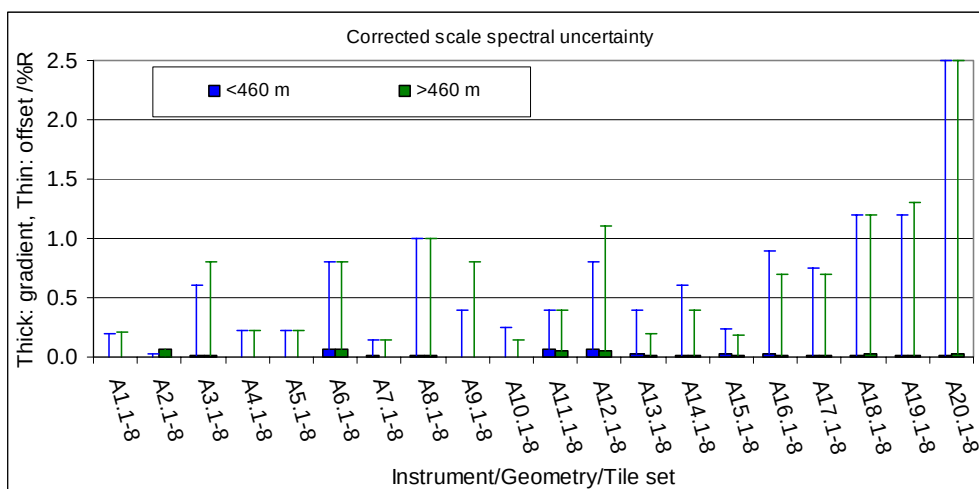


Figure 6-3 rescaled to see detail

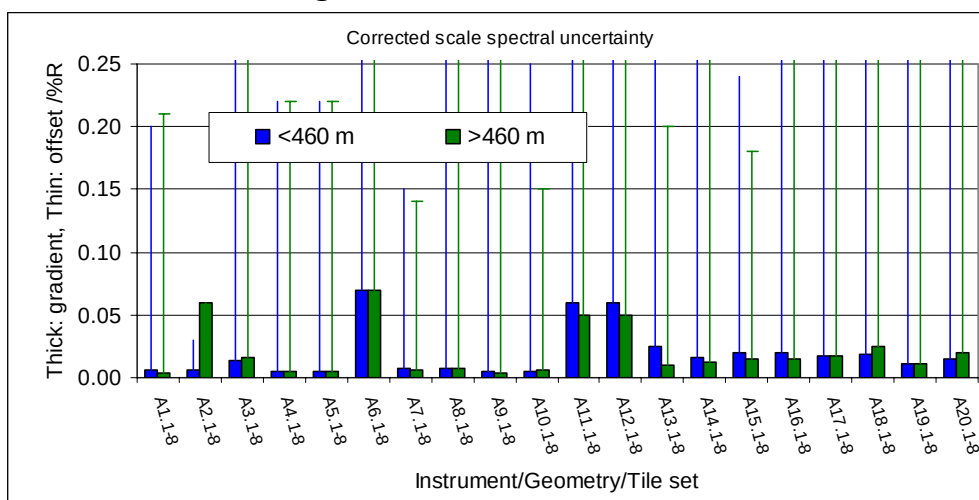


Figure 6-4: Corrected scale colorimetric differences.
Thick bars are median, thin T's are maximum.

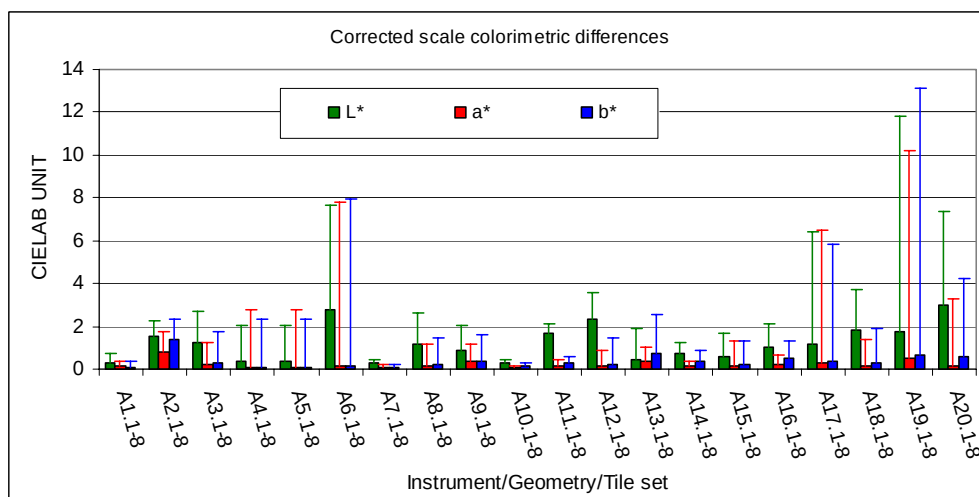


Table 6-3: Improvements to scale (reduction in uncertainty

Measurement condition					Median			Maximum			Uncertainty in form $y=mR(\lambda)+c$			
Instrument	Aperture Large/Med/ Small	Geometry	Tile finish, Glossy/Matt	Section	L*	a*	b*	L*	a*	b*	$\leq 460\text{ m}$	$\leq 460\text{ c}$	$> 460\text{ m}$	$> 460\text{ c}$
1	L	IN	G	A1	0.11	-0.03	0.02	0.04	-0.09	-0.01	0.002	0.050	0.005	-0.010
1	M	IN	G	A2	0.05	-0.60	-1.26	0.24	-0.78	-0.63	0.059	-0.010	0.005	0.010
1	S	IN	G	A3	0.22	0.03	0.09	0.13	-0.01	0.02	0.006	0.000	0.009	0.000
1	L	EX	G	A4	0.14	0.01	0.08	0.32	0.17	0.77	0.004	0.080	0.005	2.280
1	M	EX	G	A5	0.01	-0.03	-0.03	-1.13	-1.74	-1.52	0.008	-0.130	0.006	-0.130
1	S	EX	G	A6	0.29	0.03	-0.05	0.09	0.30	-0.27	0.010	-0.100	0.010	0.000
1	L	IN	M	A7	0.20	0.08	0.02	0.32	0.12	0.23	0.004	-0.050	0.004	0.110
1	M	IN	M	A8	-0.19	-0.01	-0.09	-0.63	-0.36	-0.46	0.003	-0.250	0.002	-0.250
1	S	IN	M	A9	0.22	-0.05	0.07	0.33	0.13	0.34	0.003	0.000	0.005	0.100
1	L	EX	M	A10	0.15	0.00	-0.08	0.18	0.05	-0.02	0.007	-0.140	0.004	0.050
1	M	EX	M	A11	0.27	0.02	-0.02	0.40	0.13	0.10	0.010	0.000	0.010	0.000
1	S	EX	M	A12	0.66	-0.02	0.08	0.35	0.12	0.17	0.010	0.000	0.020	0.000
2		45/0	G	A13	0.17	-0.17	-0.42	0.45	1.10	-0.71	0.000	-0.150	0.005	0.050
2		45/0	M	A14	0.18	0.17	0.40	0.12	0.44	0.55	0.009	0.300	0.007	0.000
3		45/0	G	A15	0.45	0.16	0.54	2.93	3.12	3.23	0.010	0.460	0.005	0.320
3		45/0	M	A16	0.45	-0.04	-0.20	1.14	0.71	0.52	-0.008	0.100	0.003	0.400
4		45/0	G	A17	0.03	-0.02	0.20	0.01	-0.23	-0.19	0.008	0.000	0.001	0.000
4		45/0	M	A18	0.03	0.01	-0.09	0.02	0.03	0.14	0.005	-0.100	0.001	0.000
5		45/0	G	A19	0.36	-0.20	-0.01	-4.24	-3.66	-5.37	0.019	0.000	0.039	-0.500
5		45/0	M	A20	-1.01	0.47	1.30	-4.14	-1.01	-0.47	0.015	0.000	0.020	-1.500

Figure 6-5: Improvements in scale spectral uncertainties.
Thick bars are R multipliers, thin T's are R offsets.

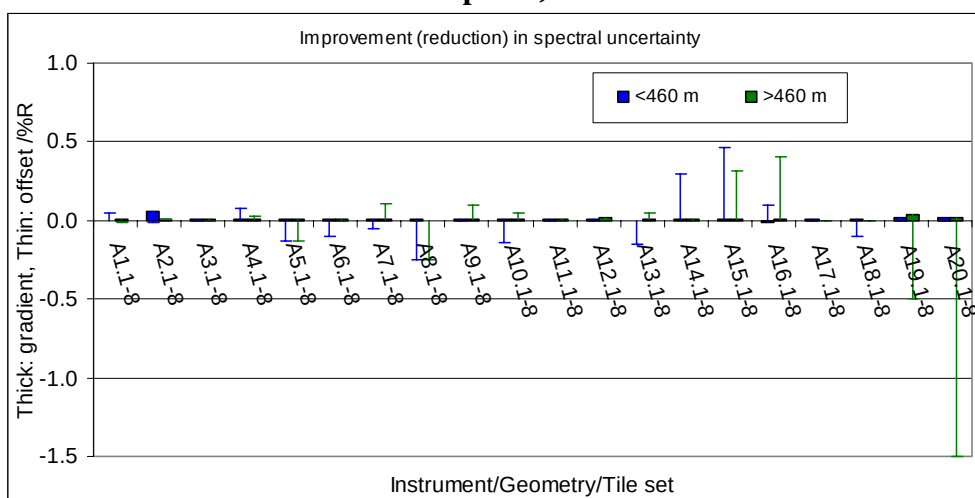


Figure 6-5 rescaled to see detail

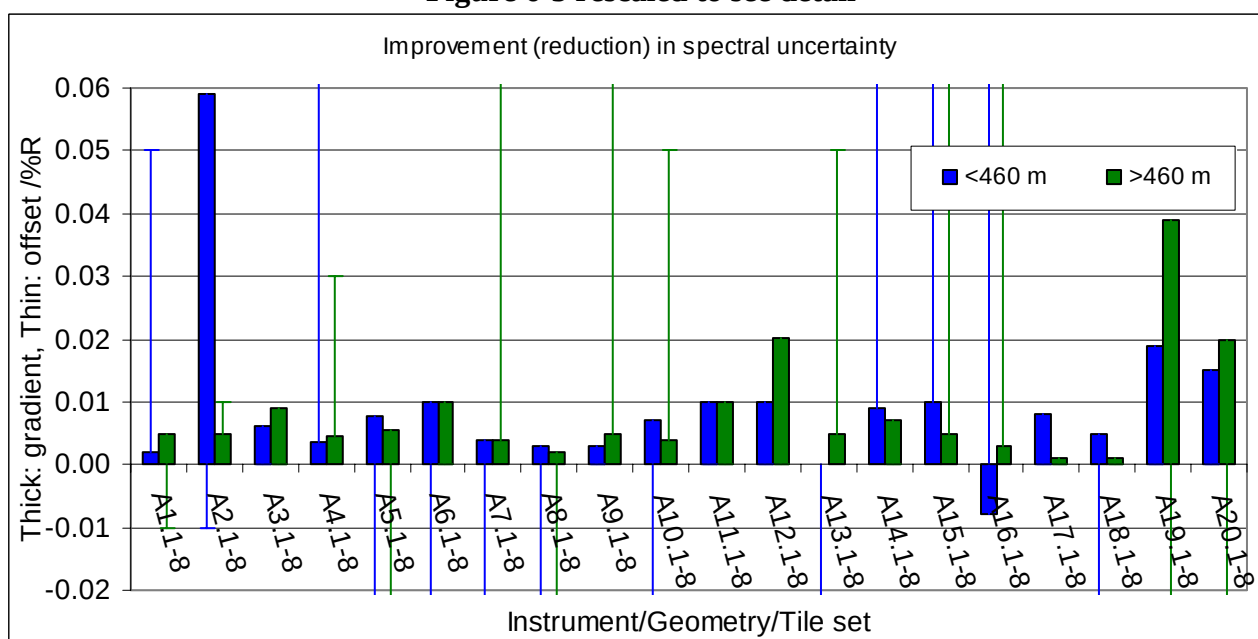
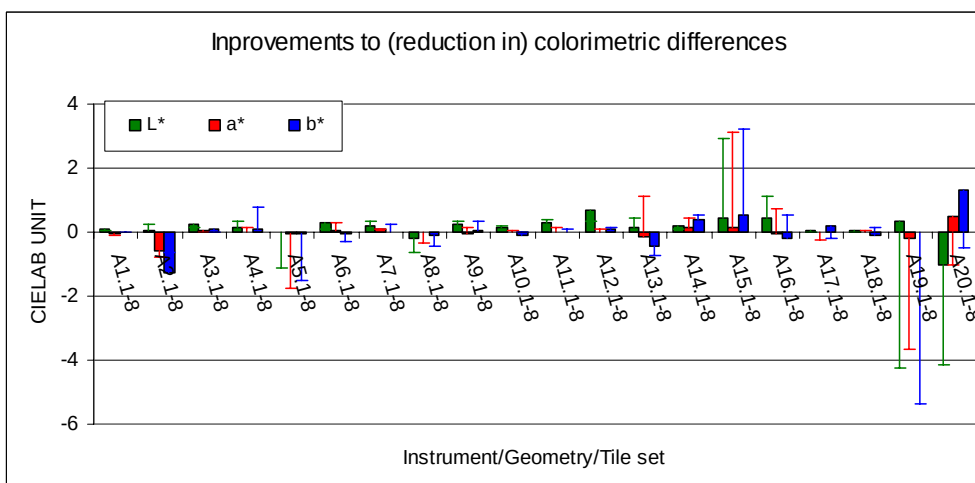


Figure 6-6: Improvements to scale colorimetric differences.
Thick bars are median, thin T's are maximum.



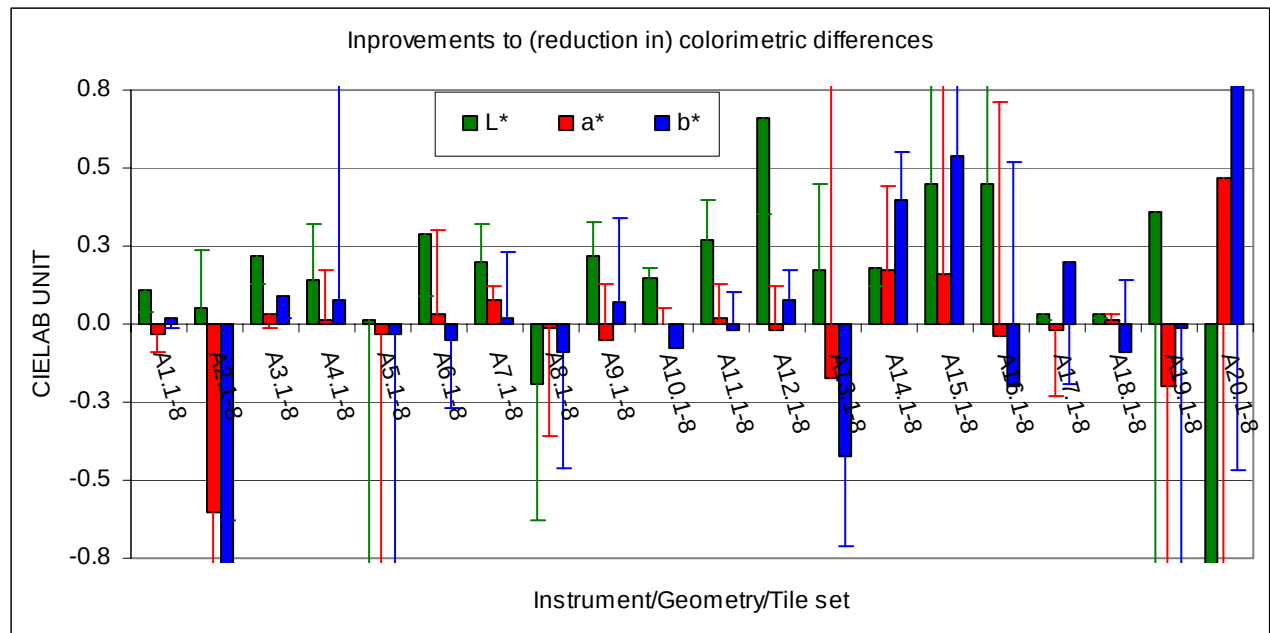


Figure 6-6 rescaled

The following comments relate to data presented in the figures in this section, and also the data sets in the appendix the figures summarise.

For uncorrected scale spectral uncertainties (Figure 6-1) trends are:

- For instrument 1, offsets increase as sample aperture size reduces. This may indicate that dark level error is due to the ill-conceived use of a silver metallic finish for the limiting aperture instead of a continuation of the sphere coating finish.
- Overall, the offset value is higher for matt tiles than for glossy ones, though measurement linearity seems to be independent of wavelength.

For uncorrected scale colorimetric differences (Figure 6.2) trends are:

- L* differences are greater than a* and b* differences – the latter two being about the same. Over all instruments and tiles, the mean medians for (L*, a*, b*) are (1.33, 0.21, 0.38), while the mean maxima are (3.09, 2.20, 2.51).
- In the best case, (L*, instrument 1, specular excluded, medium aperture, matt tiles) the maximum colorimetric difference is about 27% higher than the median, in the worst case (b*, instrument 1, specular excluded, small aperture, glossy tiles) it is about 64% higher.
- On average, the median values suggest that instrument 1 performs closer to NPL instrumentation than the other instruments. The mean medians (L*, a*, b*) for instrument 1 being (1.28, 0.16, 0.18) compared with (1.41, 0.29, 0.69) for other instruments combined. When small aperture results are removed from the instrument 1 data set, instrument 1 performs significantly better, with the mean medians becoming (0.85, 0.13, 0.12). The likely reason for this is that accuracy depends on the amount of light collected (and instrument 1 collects much more light than the others).

- For instrument 1, in common with spectral uncertainties, colorimetric accuracy gets worse with decrease in measurement aperture size.
- Comparing glossy tiles with matt tiles, overall, matt tiles had slightly higher median L^* , a^* , b^* differences than glossy ones, though the glossy tiles tended to have higher maxima than matt ones. These trends are true for instrument 1, a sphere instrument, and the other 45/0 instruments.
- For most (but not all) instruments, the deep blue and black tile results are most different in L^* from NPL values, while the deep blue is usually the tile with the greatest difference in a^* and b^* . The red tile also tends to have greater differences than most.
- For instrument 1, the maxima are generally higher for specular excluded than for specular included. This may well be due to the different ways instrument 1, and the NPL reference instrument deal with the specular component.

The data given in Table 6-3 and illustrated in Figure 6-5 and Figure 6-6 indicate the improvement (i.e. reduction in differences and uncertainties) in measurements and are the data of Table 6-1 (depicted in Figure 6-1 and Figure 6-2) minus the data of Table 6-2 (shown in Figure 6-3 and Figure 6-4). Positive values indicate a reduction in difference or uncertainty.

For improvements in spectral uncertainties (Figure 6-5) trends are:

- In all but one case, (instrument 3, matt tiles), the methods employed in this study improved the gradient of the linearity model - reducing it by about a third. The most marked improvements in gradient are for instrument 5, however, this instrument also suffers the worst change in offset factor. Offset characteristics are improved for instruments 2 and 3, though on the whole there is little change for ≤ 460 nm, and a definite worsening of the value for >460 nm.
- Changes in spectral uncertainties are better for glossy tiles than matt tiles in many cases.

For improvements in colorimetric differences (Figure 6-6) trends are:

- On the whole, there is a 11% improvement in the median difference between L^* as measured by the instruments and the NPL reference values, with improvements for glossy tiles double that for matt ones – except in the case of instrument 1 where matt tiles improved more.
- The median difference in a^* increased by 5% and diminished for b^* by 7% over all instruments and tiles. The medium sized aperture results for instrument 1 fare particularly badly. The method seems to work better for all other instruments, with average reductions in the median difference in a^* and b^* of 17% and 31% respectively. The median values improve more for matt tiles than for glossy ones.
- Instrument 3 benefits most from the scale correction. The median difference in L^* is almost halved, and there are significant improvements in a^* and b^* differences, for

glossy, though not for matt tiles. This instrument also has the most spectacular decrease in maximum differences – for matt tiles, L^* , a^* and b^* difference maxima diminish to about a third of their original values.

- Maximum differences are reduced in most cases for most instruments. The exceptions are instrument 5 which had increases between 12% (for b^* matt tiles) and 128% (for L^* matt tiles), and (usually) the medium aperture measurements made with instrument 1. Excluding these instruments, improvements are between 15% and 33%.
- For instrument 1, median differences in a^* and b^* are worse for specular included (by 52% and 94% respectively), remain the same for specular excluded geometry while L^* differences in both geometries improve by about 12%. There is a greater improvement in linearity for specular included geometry than for specular excluded.

7 CONCLUSIONS

7.1 *Uncertainties in measurement of reflected colour using diode-array instrumentation*

This report demonstrates typical measurement uncertainties one might expect to achieve using a diode-array spectrophotometer. The overall ‘out of the box’ performance of the five instruments investigated is summarised in Table 7. 1.

Table 7. 1: ‘Performance’ of diode-array instruments compared

	Median differences instrument-NPL			Maximum differences instrument-NPL		
	L^*	a^*	b^*	L^*	a^*	b^*
Instrument 1 SPIN	1.00	0.19	0.20	1.87	0.81	1.22
Instrument 1 SPEX	1.56	0.13	0.16	3.01	2.32	2.37
Instruments 2-4	1.19	0.22	0.49	3.63	2.74	2.87
Instrument 5	2.07	0.48	1.29	5.40	4.44	5.76

Measurements made in specular included geometry with instrument 1 appear to be the most accurate, followed by those on the same instrument made in specular excluded geometry. This is probably because there is more light collected in these sphere geometries, than for the 45/0 measurements made by the other instruments. The poorer performance in specular excluded geometry may be due to the different way the instrument deals with the specular component of light to that employed in the NPL master instrument.

Instrument 5 performs the poorest. This is possibly related to the amount of light available for measurement too – this instrument probably has the shortest integration time, and measures a comparatively small area.

7.2 Recommended calibration protocols

7.2.1 Traceability

To understand the true uncertainty of any measurement one must include a calibrated, traceable artefact with a known uncertainty as part of the measurement and evaluation process.

A spectrophotometer will often be supplied with a so-called calibration standard, the measurement of which forms part of the start-up procedure, indeed the instrument may not permit further measurements until this one has been done. The system will give a warning, and possibly refuse to function further, if the measured tile values differ significantly from stored values. This procedure usually evaluates no more than the repeatability of the system between this measurement, and when the instrument was last serviced, (or even earlier).

The user seldom knows the scale uncertainty of the standard used in this process – which we shall call **validation**, or what the limit of acceptance for the pass/fail tile test is, and any uncertainty budget without these data is incomplete if the results are to be used in an absolute rather than a relative sense.

Calibrating an instrument ascribes a scale to it, usually by means of an artefact similar in nature to the type of sample the instrument is being used to measure (to minimise the effects of instrumental errors which may vary, for example, with surface properties).

7.2.2 Recommended Calibration Protocols

This report highlights areas in which uncertainty arises in diode-array spectrophotometer measurements and demonstrates the application of some calibration protocols to reduce some of these uncertainties. These are summarised in Table 7. 2.

Table 7. 2: Uncertainty contributors in diode-array spectrophotometry

Item	Quantity evaluated	Measurements	Correction possible	Uncertainty
1	Repeatability (stly derived from ‘photometric’ noise due to the statistical nature of light, and thus related to the amount of light collected).	Measure item 15 times, take standard error of mean.	No correction is possible. This is an assessment of uncertainty.	Statistics may determine what repeatability may be achieved from a smaller number of measurements.
2	Thermochromism	Previously evaluated thermochromic evaluation.	May be applied to ceramic tile data to account for changes in colour due to temperature.	Reduces an uncertainty introduced in assessments using ceramic colour standards.
3	Spectrophotometric Linearity.	Measure neutral samples.	Correct results using an evaluated linearity profile.	Uncertainty seems to be reduced in some but not all cases in this study using this method.
4	Bandwidth.	Not evaluated in this report.	Not at present.	A potentially major contributor to uncertainty but for these instruments an un-measurable quantity.

5	Geometry.	This report suggests that geometry has a bearing on achievable accuracy, both in terms of how much light is collected, and the method used.	Correction requires a deep understanding of instrumentation and samples measured which are probably impractical to evaluate.	A potentially major contributor to uncertainty but for these instruments an un-measurable quantity.
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In another project at NPL, the reduction of uncertainties is approached using a technique called ‘MET – Measurement Enhancement and Traceability’ [4]. This uses a different approach to investigate linearity, and also investigates some geometric issues such as specular collection using a mirror.

A calibration system (ON-MET) [5] has also been developed at NPL using Internet technology to send data from instruments to a central co-ordinator who is responsible for maintaining long-term records and sending back correction factors to improve results.

7.4 Suggestions for future related work

At the offset of this project, it was realised that bandwidth is a major contributor to uncertainty in diode-array spectrophotometers. Some attempts were made to investigate this aspect, however, at this time no suitable techniques or standards are available. It is recommended that this situation be reviewed again in the future.

The samples used in this investigation were ceramic tiles. The two surface finishes – matt and glossy, along with the different spectral characteristics – represented a range of possible measurement materials, though it is possible that textiles, plastics and painted surfaces – which diode-array instrumentation are regularly used to measure – will perform in different ways. It may be valuable to extend application of the methods described in this report to include such samples of more direct industrial relevance.

Colour measurement technology is changing fast. 15 years ago, diode-array technology was expensive and inaccurate, with speed being its only attractive feature. As cost and resolution of detectors continues diminishing, and their quality increasing, it is possible that the quality of measurements will improve, although the statistical nature of light will continue to limit overall accuracy. Reasonably priced multi-angle instrumentation is likely to become the next stage in the evolution of these instruments, and it is important that uncertainty evaluations are carried out – in a similar or extended form – on these new technologies.

Uncertainties in the master set of data used in this report are given in the table headed ‘NPL Lambda Uncertainty’ on the first sheet for each instrument in the appendix. In some cases, these values approach the uncertainties being quoted for diode-array instruments. The methods reported in this document could be significantly improved with a more accurate set of initial master data. A limit to the accuracy of the master data set is the fact the measurements were made on a sphere-based instrument, thereby introducing instrument specific geometric related errors. There are advances at NPL to establish a goniometrically based scale which is less prone to geometric uncertainty issues, and master data obtained by that method should prove a finer tool for investigating uncertainties and errors elsewhere.

Uncertainties in this study were as evaluated at the time of the experimental stage of the investigation. It is likely that the scales of the instruments will drift with time, and the size of this drift, and how well it is checked by ‘calibration’ procedures will vary significantly from one instrument to another. Some instruments reset their scale each time they are used. Others require a major reset once they have drifted beyond a certain stage – or when they are serviced. The NPL laboratory environment is considerably cleaner than many industrial settings, and the instrumentation is used less intensively at NPL than in industry. This dimension is not tackled in this study. A possible avenue for further study is the long-term performance of diode-array instrumentation in industrial situations, and whether the intervals and degree of recalibration is sufficient.

8 REFERENCES

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- [3] Guide to the expression of uncertainty in measurement, International Organisation for Standardisation, Geneva (1993).
- [4] Clarke, P.J., The NPL correction kit for enhanced and traceable reflectance measurement, *Proc 4th Oxford Conference*, SPIE, Vol. 4826, 123-128 (2002).
- [5] Prince, S.R., iColour: remote monitoring/calibration of spectrophotometers using the internet, *Proc 4th Oxford Conference*, SPIE, Vol. 4826, 181-188 (2002).

9. Appendix

Index to Summary data and results

Section pages	Instrument	Aperture	Geometry	Tile finish
A1.1-8	1	Large	SPIN	Gloss
A2.1-8	1	Medium	SPIN	Gloss
A3.1-8	1	Small	SPIN	Gloss
A4.1-8	1	Large	SPEX	Gloss
A5.1-8	1	Medium	SPEX	Gloss
A6.1-8	1	Small	SPEX	Gloss
A7.1-8	1	Large	SPIN	Matt
A8.1-8	1	Medium	SPIN	Matt
A9.1-8	1	Small	SPIN	Matt
A10.1-8	1	Large	SPEX	Matt
A11.1-8	1	Medium	SPEX	Matt
A12.1-8	1	Small	SPEX	Matt
A13.1-8	2		45/0	Gloss
A14.1-8	2		45/0	Matt
A15.1-8	3		45/0	Gloss
A16.1-8	3		45/0	Matt
A17.1-8	4		45/0	Gloss
A18.1-8	4		45/0	Matt
A19.1-8	5		45/0	Gloss
A20.1-8	5		45/0	Matt

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 25 mm (Large)

Geometry: SPIN

Tiles: Gloss

NPL Master Tiles: Colours Set ½

White WT53

Black BT03

Grey GT51

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0077	R%	+	0.2407
450 nm	Uncert =	0.0064	R%	+	0.1353
500 nm	Uncert =	0.0097	R%	+	0.1744
550 nm	Uncert =	0.0086	R%	+	0.1723
600 nm	Uncert =	0.0090	R%	+	0.1930
650 nm	Uncert =	0.0081	R%	+	0.1962
700 nm	Uncert =	0.0105	R%	+	0.1803

<= 460 nm Uncert = **0.008** R% + **0.250** (k = 2)

>= 465 nm Uncert = **0.009** R% + **0.200** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	0.42	0.74
a*	0.09	0.24
b*	0.10	0.38

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0051	R%	+	0.1971
450 nm	Uncert =	0.0054	R%	+	0.1453
500 nm	Uncert =	0.0056	R%	+	0.1309
550 nm	Uncert =	0.0051	R%	+	0.1822
600 nm	Uncert =	0.0052	R%	+	0.1826
650 nm	Uncert =	0.0056	R%	+	0.1954
700 nm	Uncert =	0.0054	R%	+	0.1716

<= 460 nm Uncert = **0.006** R% + **0.200** (k = 2)

>= 460 nm Uncert = **0.004** R% + **0.210** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	0.31	0.70
a*	0.12	0.33
b*	0.08	0.39

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.01	0.77	0.45	0.45	0.28	0.34	0.33	0.56	0.81	0.41	0.41	0.39	0.25	0.24	0.65
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	0.0012	0.0030	0.0013	0.0007	0.0004	0.0004	0.0007	0.0012	0.0003	< 0.0001
y	< 0.0001	< 0.0001	< 0.0001	0.0001	0.0005	< 0.0001	0.0003	0.0007	0.0008	0.0010	0.0011	0.0005	0.0021	0.0008	< 0.0001
L*	0.42	0.41	0.41	0.41	0.55	0.46	0.48	0.41	0.41	0.42	0.42	0.43	0.69	0.74	0.40
a*	< 0.01	< 0.01	0.01	0.02	0.05	0.13	0.24	0.10	0.16	0.19	0.19	0.07	0.14	0.09	< 0.01
b*	0.02	< 0.01	0.02	0.03	0.10	0.10	0.38	0.36	0.23	0.10	0.12	0.04	0.20	0.14	< 0.01

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

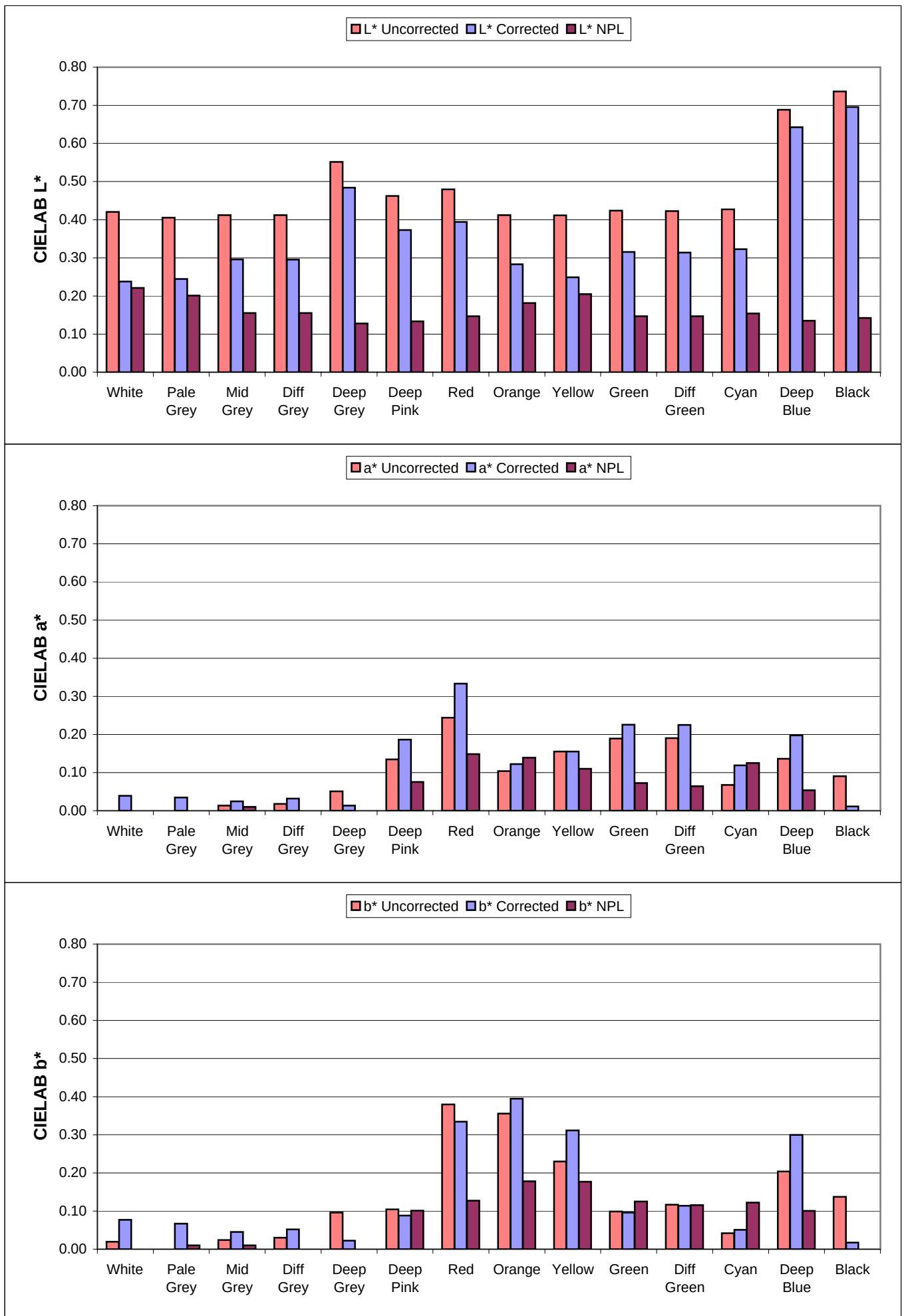
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.57	0.46	0.32	0.32	0.25	0.27	0.27	0.38	0.49	0.30	0.30	0.30	0.23	0.23	0.41
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0012	0.0029	0.0013	0.0007	0.0005	0.0004	0.0007	0.0014	0.0002	< 0.0001
y	0.0002	0.0002	0.0001	0.0002	0.0001	0.0001	0.0001	0.0006	0.0007	0.0009	0.0010	0.0004	0.0025	0.0001	0.0002
L*	0.24	0.24	0.30	0.30	0.48	0.37	0.39	0.28	0.25	0.32	0.31	0.32	0.64	0.70	0.25
a*	0.04	0.03	0.02	0.03	0.01	0.19	0.33	0.12	0.16	0.23	0.22	0.12	0.20	0.01	0.03
b*	0.08	0.07	0.04	0.05	0.02	0.09	0.33	0.39	0.31	0.10	0.11	0.05	0.30	0.02	0.06

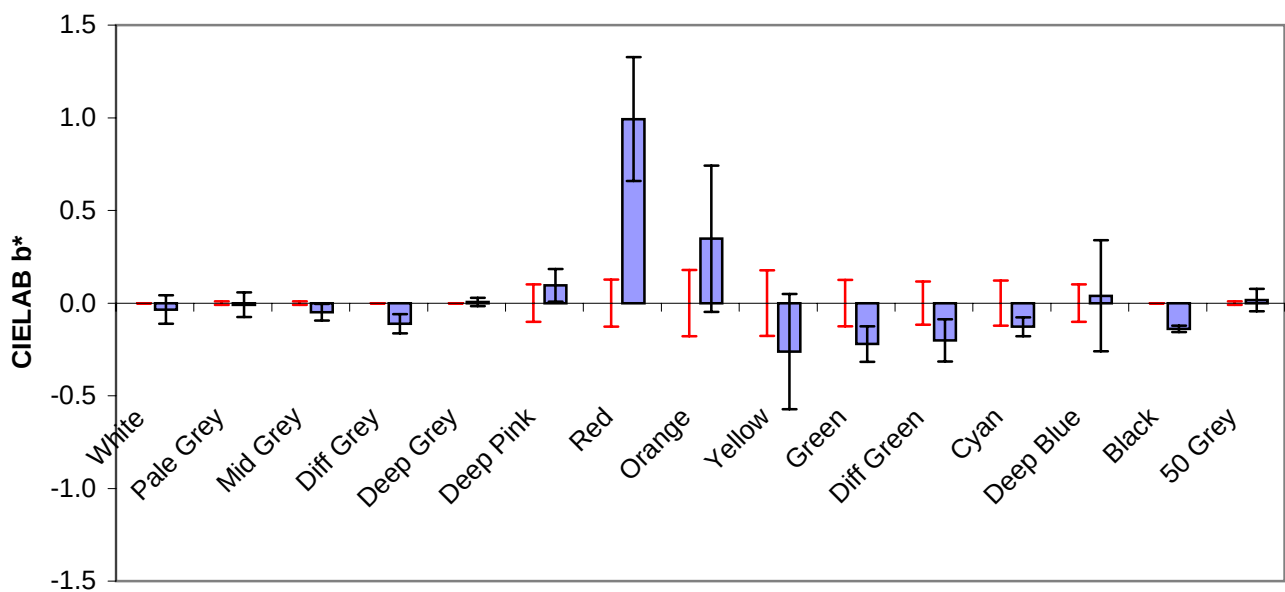
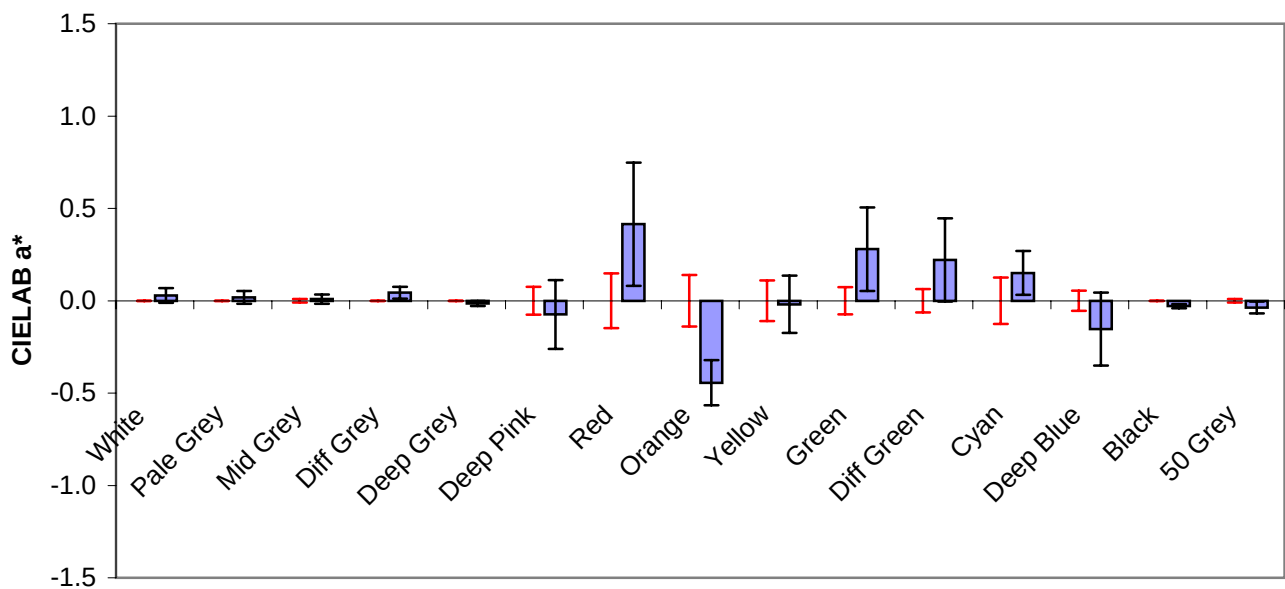
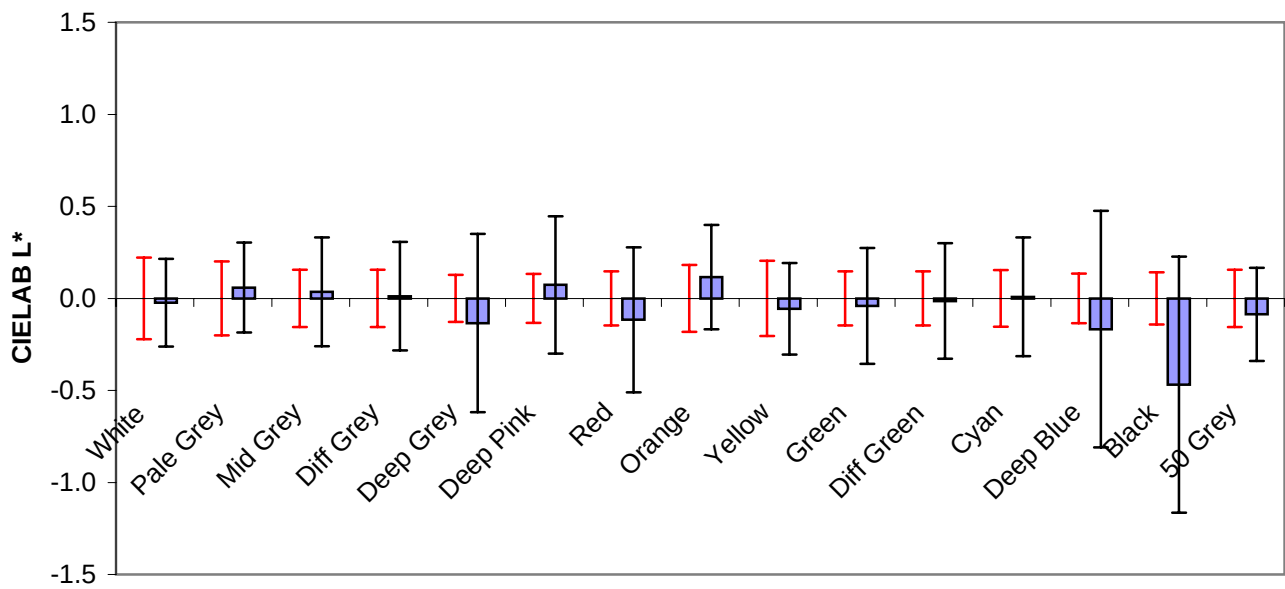
NPL Lambda Uncertainty

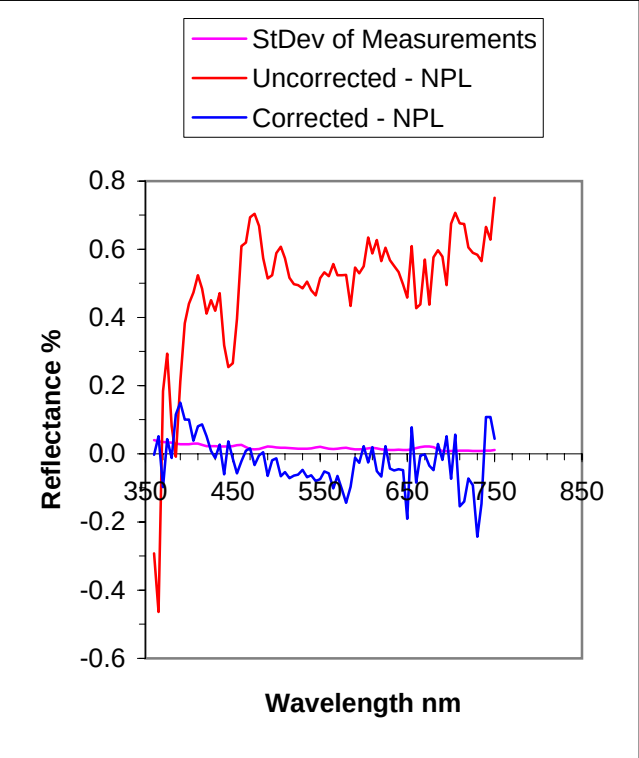
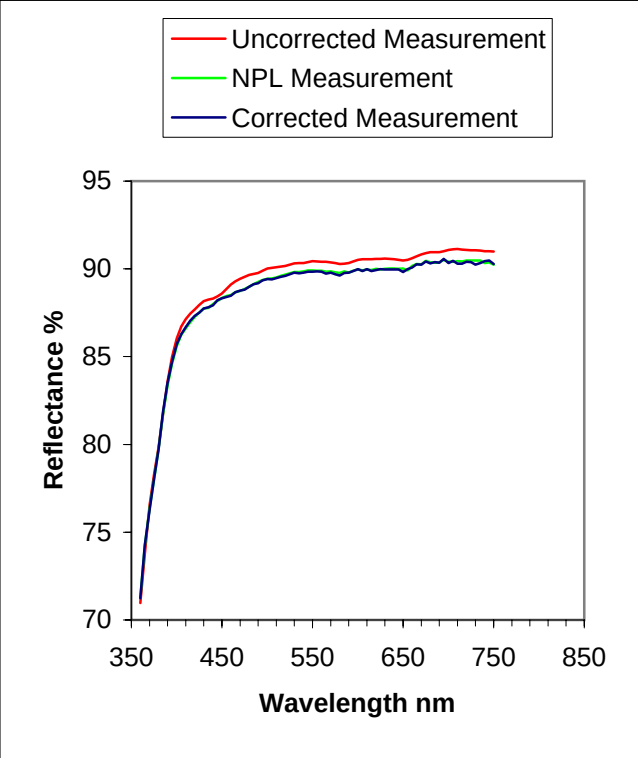
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.54	0.38	0.16	0.16	0.06	0.10	0.10	0.24	0.39	0.15	0.15	0.15	0.05	0.05	0.16
x	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004	0.0007	0.0002	0.0003	0.0003	0.0003	0.0001	0.0004	< 0.0001	< 0.0001
y	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	0.0001	0.0003	0.0001	0.0004	0.0004	0.0004	0.0005	< 0.0001	< 0.0001
L*	0.22	0.20	0.16	0.16	0.13	0.13	0.15	0.18	0.20	0.15	0.15	0.15	0.13	0.14	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.08	0.15	0.14	0.11	0.07	0.06	0.13	0.05	< 0.01	0.01
b*	< 0.01	0.01	0.01	< 0.01	< 0.01	0.10	0.13	0.18	0.18	0.13	0.12	0.12	0.10	< 0.01	0.01

Colorimetry

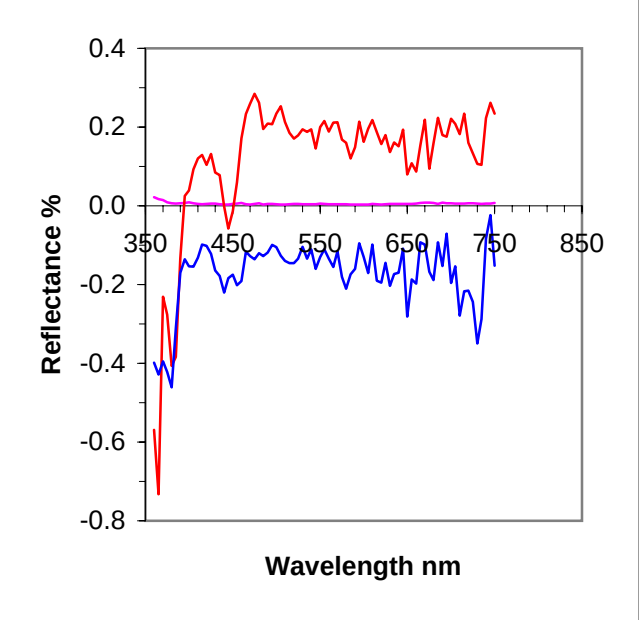
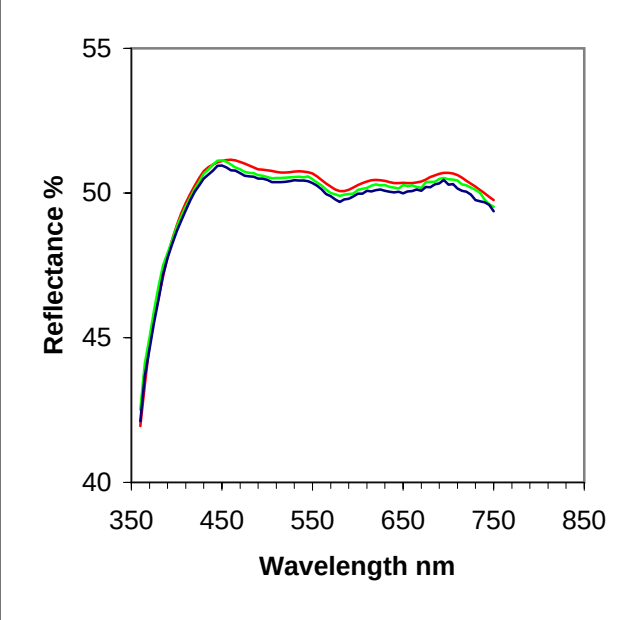
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	96.13	83.58	59.16	59.35	35.70	45.79	44.27	68.37	85.40	55.01	55.22	53.42	27.70	25.79	76.38
		a*	-0.34	-0.45	-0.41	-2.42	-0.33	25.26	42.65	37.02	-4.90	-29.56	-29.92	-10.52	9.05	-0.39	-0.16
		b*	1.05	0.31	0.10	1.99	0.42	4.76	21.65	53.84	76.55	11.98	14.82	-30.10	-17.65	-0.51	-0.43
Average Measurement (Uncorrected)	B	L*	96.12	83.60	59.15	59.35	35.70	45.77	44.23	68.32	85.38	54.99	55.22	53.40	27.70	25.78	76.38
		a*	-0.34	-0.47	-0.42	-2.42	-0.32	25.21	42.58	37.10	-4.86	-29.57	-29.89	-10.49	9.04	-0.40	-0.15
		b*	1.05	0.32	0.11	2.00	0.42	4.73	21.57	53.84	76.61	12.00	14.82	-30.10	-17.62	-0.51	-0.43
Average Measurement (Corrected)	C	L*	95.88	83.38	58.99	59.19	35.59	45.64	44.10	68.14	85.16	54.84	55.06	53.25	27.61	25.69	76.18
		a*	-0.30	-0.44	-0.40	-2.39	-0.31	25.17	42.49	37.03	-4.86	-29.50	-29.82	-10.42	9.05	-0.39	-0.13
		b*	0.98	0.26	0.06	1.96	0.38	4.68	21.49	53.69	76.42	11.95	14.76	-30.08	-17.62	-0.54	-0.49
NPL Values	D	L*	95.90	83.32	58.95	59.18	35.72	45.57	44.22	68.02	85.22	54.88	55.08	53.24	27.77	26.16	76.27
		a*	-0.33	-0.45	-0.40	-2.44	-0.29	25.24	42.07	37.47	-4.84	-29.78	-30.04	-10.57	9.20	-0.36	-0.09
		b*	1.02	0.27	0.11	2.07	0.38	4.58	20.50	53.35	76.68	12.17	14.97	-29.95	-17.66	-0.40	-0.50
A to B		dE*	0.012	0.024	0.015	0.013	0.007	0.062	0.117	0.091	0.071	0.034	0.026	0.035	0.032	0.013	0.002
B to C		dE*	0.254	0.226	0.170	0.172	0.117	0.149	0.175	0.250	0.286	0.179	0.180	0.167	0.095	0.095	0.209
B to D		dE*	0.222	0.280	0.199	0.187	0.053	0.257	1.181	0.689	0.184	0.287	0.248	0.229	0.185	0.398	0.148
C to D		dE*	0.051	0.062	0.062	0.120	0.135	0.142	1.082	0.576	0.268	0.358	0.299	0.198	0.230	0.490	0.096
Corrected + Uncertainty	E	L*	96.12	83.62	59.28	59.48	36.07	46.01	44.50	68.42	85.41	55.15	55.38	53.58	28.25	26.38	76.44
		a*	-0.26	-0.40	-0.37	-2.36	-0.29	25.36	42.82	37.15	-4.70	-29.27	-29.59	-10.30	9.24	-0.38	-0.09
		b*	1.06	0.33	0.11	2.01	0.41	4.77	21.83	54.09	76.73	12.05	14.88	-30.03	-17.32	-0.52	-0.43
Corrected - Uncertainty	F	L*	95.64	83.14	58.69	58.89	35.10	45.27	43.71	67.86	84.92	54.52	54.75	52.93	26.96	24.99	75.93
		a*	-0.34	-0.47	-0.42	-2.42	-0.32	24.98	42.16	36.90	-5.01	-29.72	-30.04	-10.54	8.85	-0.40	-0.16
		b*	0.91	0.19	0.02	1.90	0.36	4.59	21.16	53.30	76.11	11.85	14.65	-30.13	-17.92	-0.56	-0.55



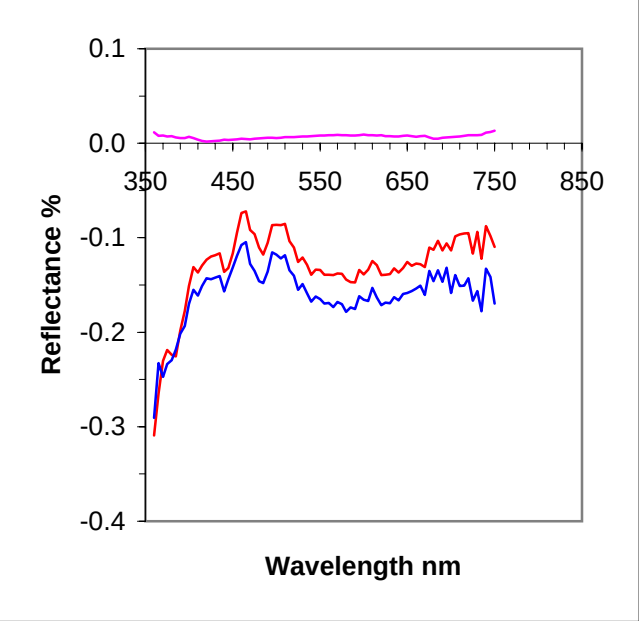
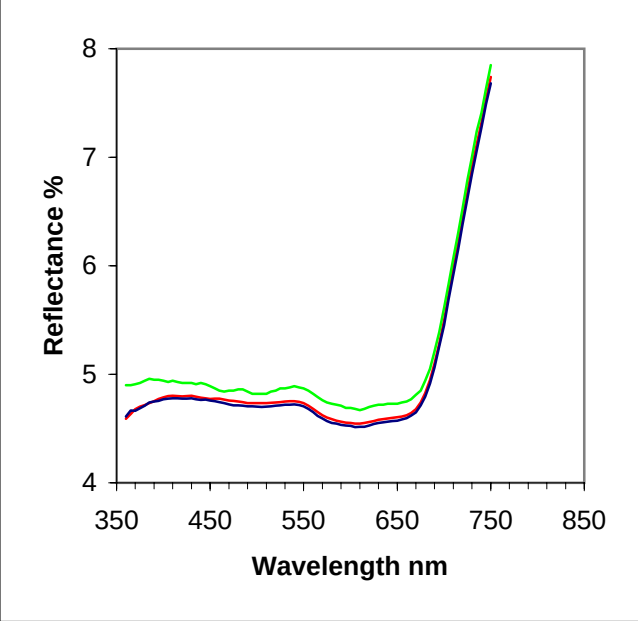




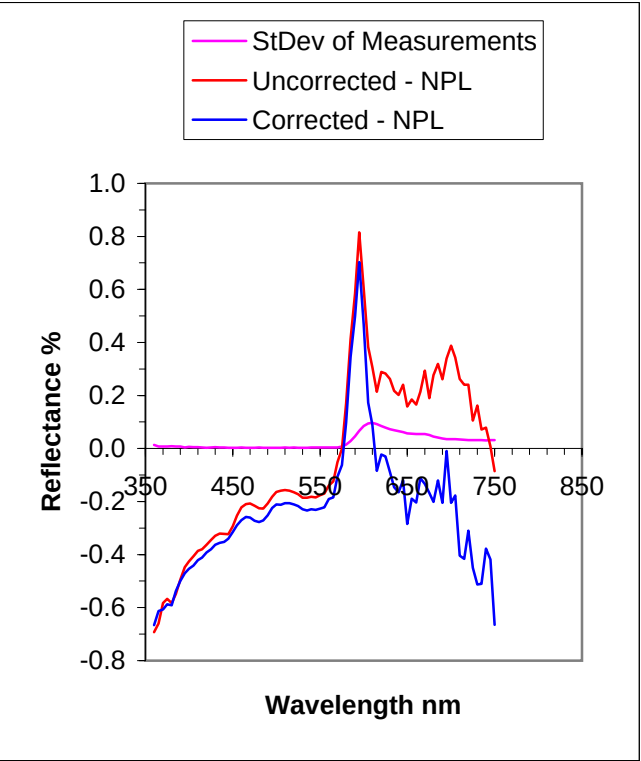
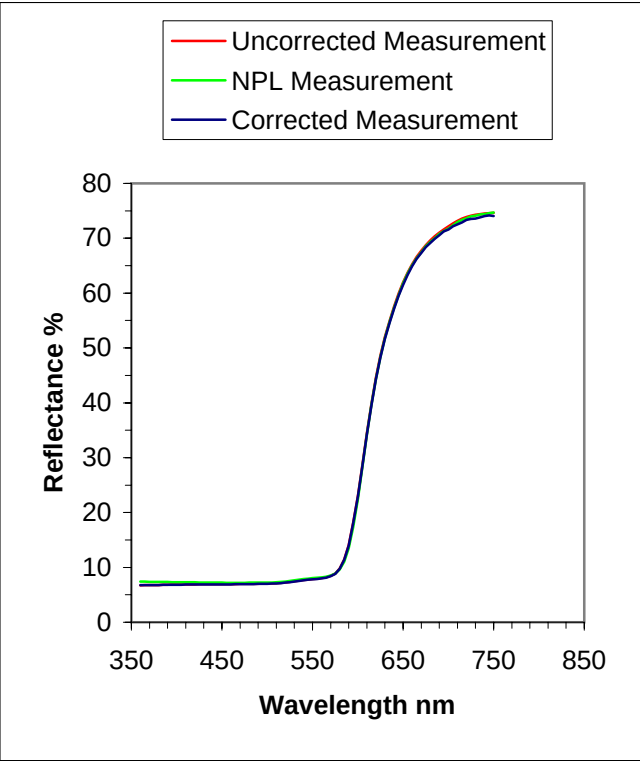
**White
Gloss**



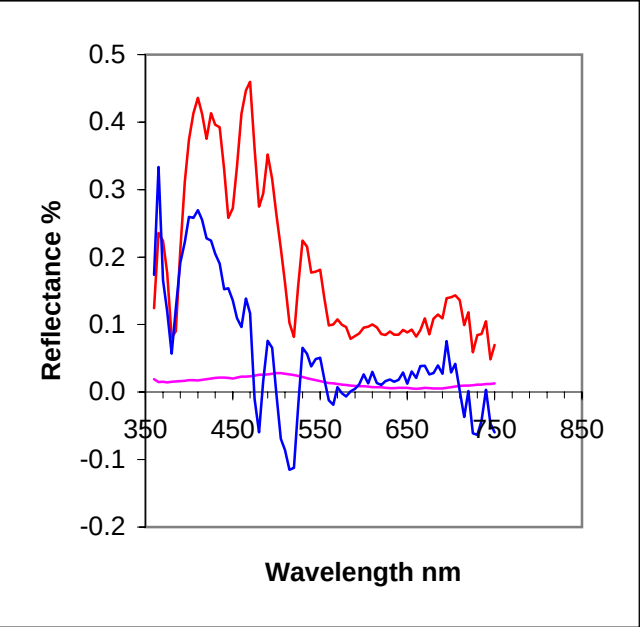
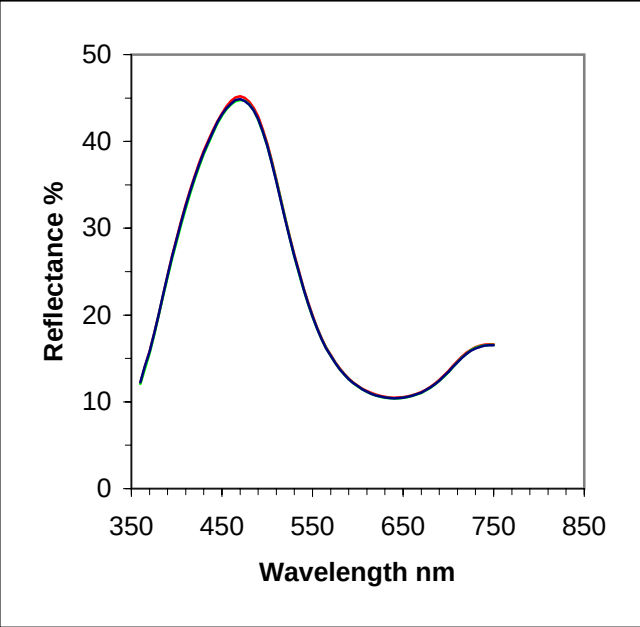
**50 Grey
Gloss**



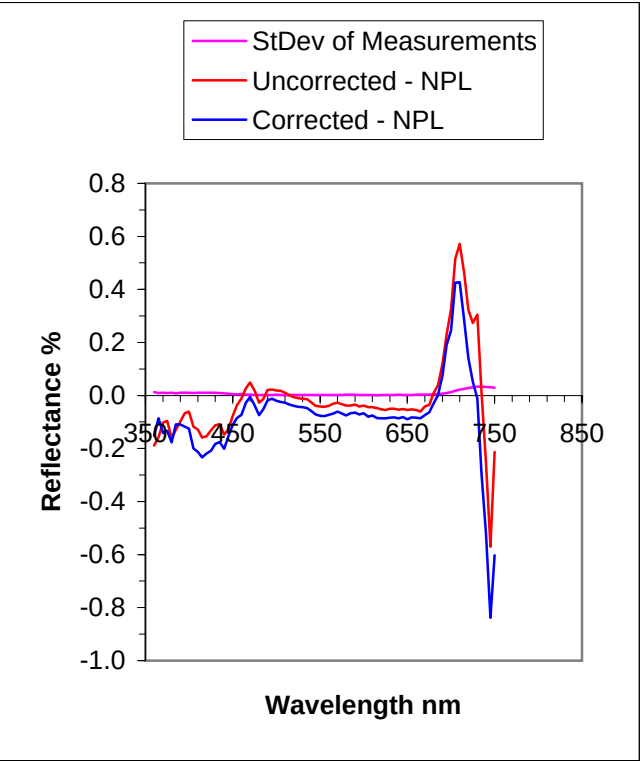
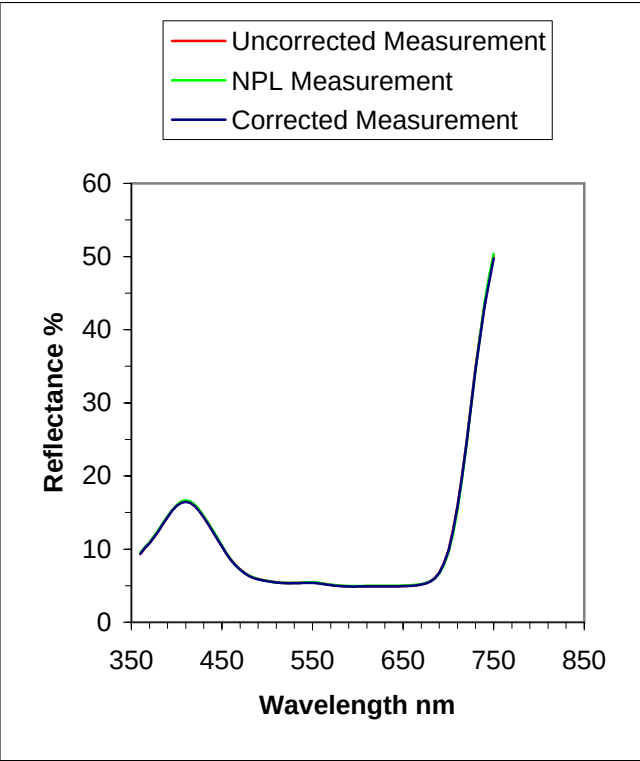
**Black
Gloss**



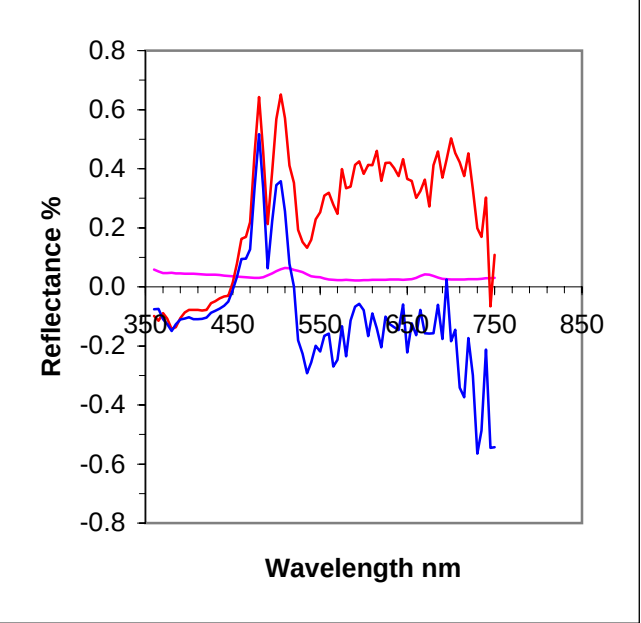
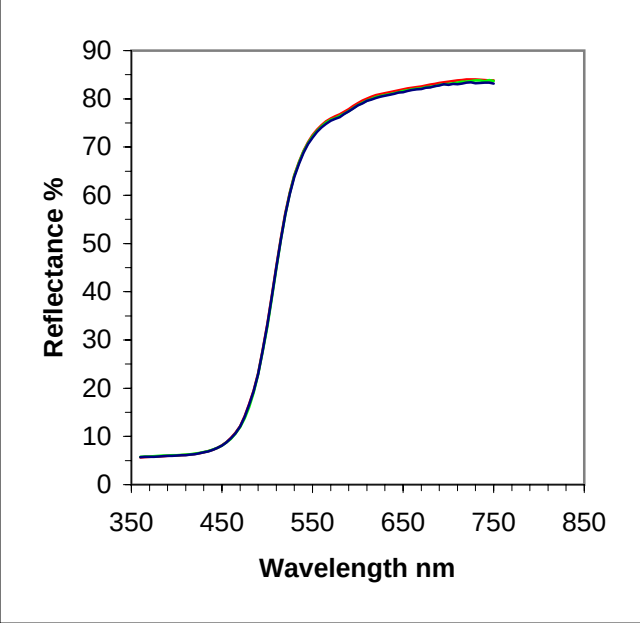
**Red
Gloss**



**Cyan
Gloss**



**Blue
Gloss**



**Yellow
Gloss**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 10 mm (Medium)

Geometry: SPIN

Tiles: Gloss

NPL Master Tiles: Colours Set ½

White WT53

Black BT03

Grey GT51

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0622	R%	+	0.0230
450 nm	Uncert =	0.0613	R%	+	-0.0264
500 nm	Uncert =	0.0644	R%	+	0.0133
550 nm	Uncert =	0.0636	R%	+	-0.0599
600 nm	Uncert =	0.0640	R%	+	-0.0158
650 nm	Uncert =	0.0631	R%	+	0.0009
700 nm	Uncert =	0.0671	R%	+	-0.0417

<= 460 nm Uncert = **0.065** R% + **0.020** (k = 2)

>= 465 nm Uncert = **0.065** R% + **0.010** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	1.61	2.53
a*	0.19	0.95
b*	0.10	1.68

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0574	R%	+	0.0273
450 nm	Uncert =	0.0574	R%	+	-0.0254
500 nm	Uncert =	0.0562	R%	+	0.0282
550 nm	Uncert =	0.0557	R%	+	-0.0562
600 nm	Uncert =	0.0568	R%	+	-0.0285
650 nm	Uncert =	0.0544	R%	+	-0.0088
700 nm	Uncert =	0.0570	R%	+	-0.0206

<= 460 nm Uncert = **0.006** R% + **0.030** (k = 2)

>= 460 nm Uncert = **0.06** R% + **0.000** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	1.46	2.29
a*	0.79	1.73
b*	1.36	2.31

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	6.16	4.31	1.86	1.87	0.62	1.04	0.96	2.62	4.55	1.57	1.58	1.46	0.38	0.33	3.45
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004	0.0007	0.0001	0.0003	0.0003	0.0003	0.0001	< 0.0001	< 0.0001	< 0.0001
y	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	0.0001	0.0004	0.0002	0.0001	0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001
L*	2.53	2.25	1.70	1.70	1.19	1.40	1.37	1.90	2.28	1.61	1.61	1.57	1.01	0.97	2.08
a*	< 0.01	< 0.01	< 0.01	0.05	< 0.01	0.57	0.95	0.84	0.19	0.66	0.66	0.23	0.21	< 0.01	< 0.01
b*	0.02	< 0.01	< 0.01	0.03	0.01	0.10	0.46	1.18	1.68	0.25	0.31	0.68	0.40	0.04	0.02

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

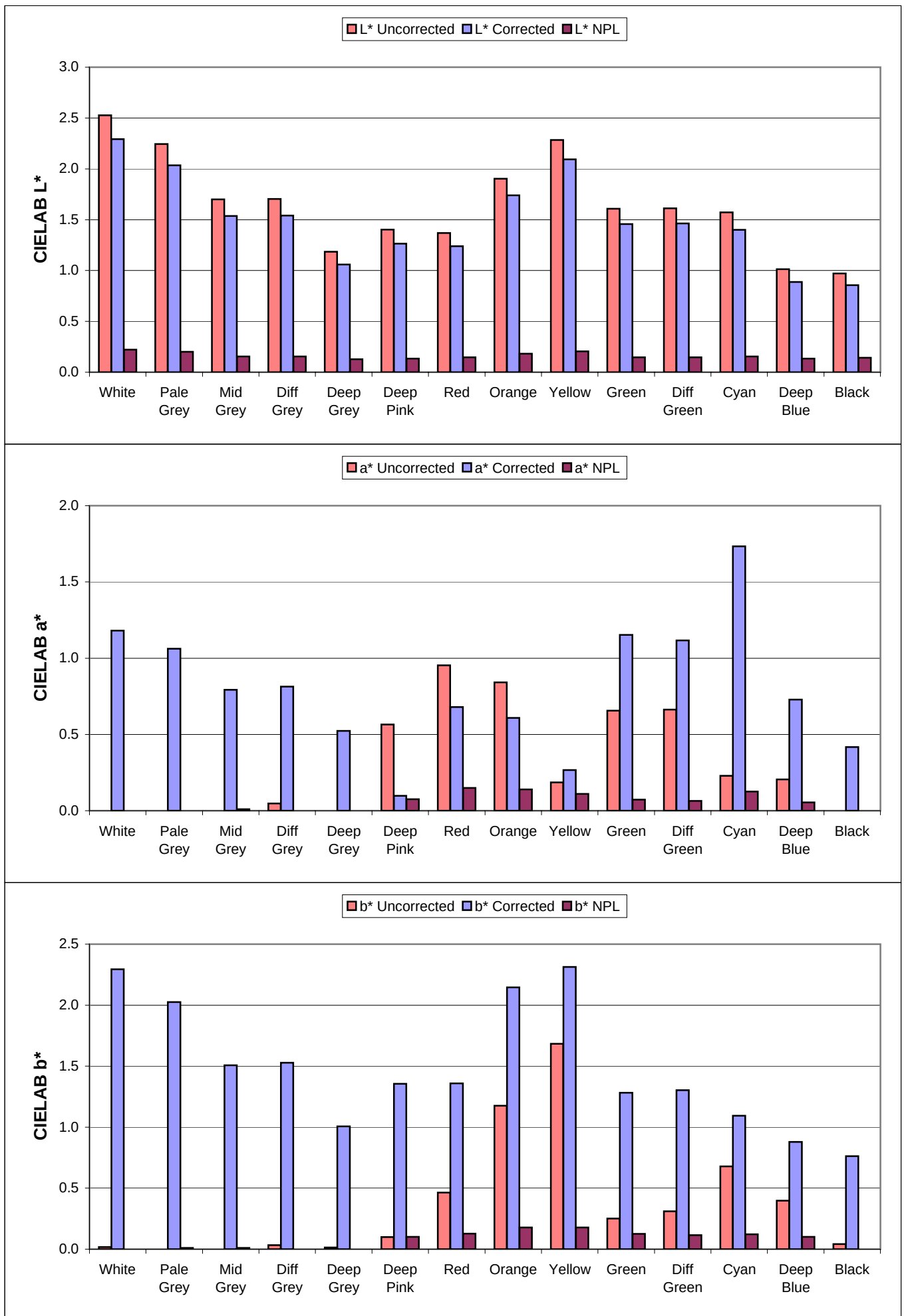
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	5.58	3.90	1.68	1.69	0.55	0.93	0.87	2.38	4.15	1.42	1.43	1.30	0.33	0.29	3.12
x	0.0024	0.0024	0.0024	0.0023	0.0023	0.0032	0.0026	0.0015	0.0008	0.0014	0.0014	0.0013	0.0025	0.0022	0.0024
y	0.0049	0.0049	0.0049	0.0049	0.0047	0.0041	0.0023	0.0017	0.0012	0.0043	0.0041	0.0054	0.0056	0.0045	0.0050
L*	2.29	2.04	1.54	1.54	1.06	1.26	1.24	1.74	2.09	1.46	1.46	1.40	0.89	0.86	1.89
a*	1.18	1.06	0.79	0.81	0.52	0.10	0.68	0.61	0.27	1.15	1.12	1.73	0.73	0.42	0.99
b*	2.29	2.03	1.51	1.53	1.01	1.36	1.36	2.15	2.31	1.28	1.30	1.09	0.88	0.76	1.88

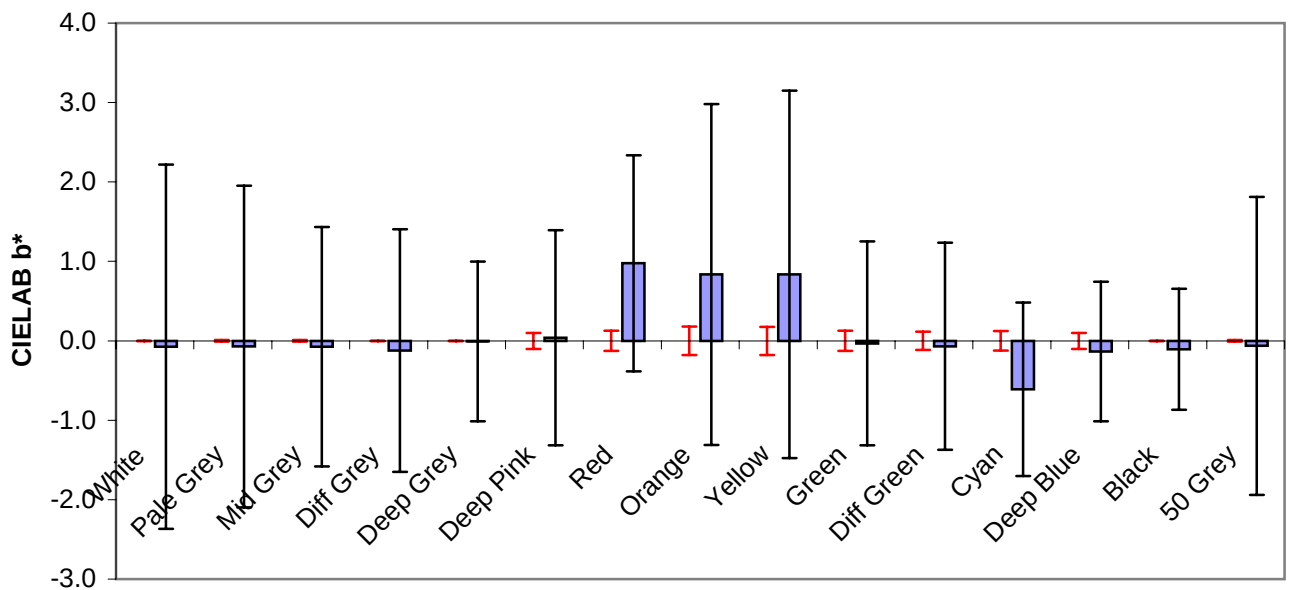
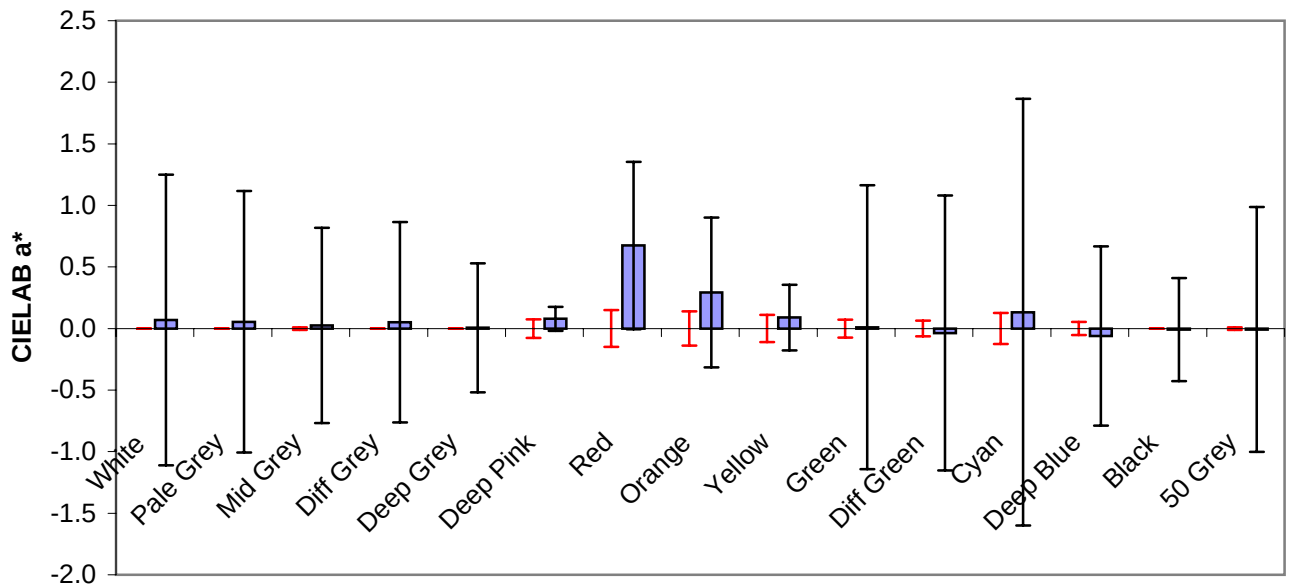
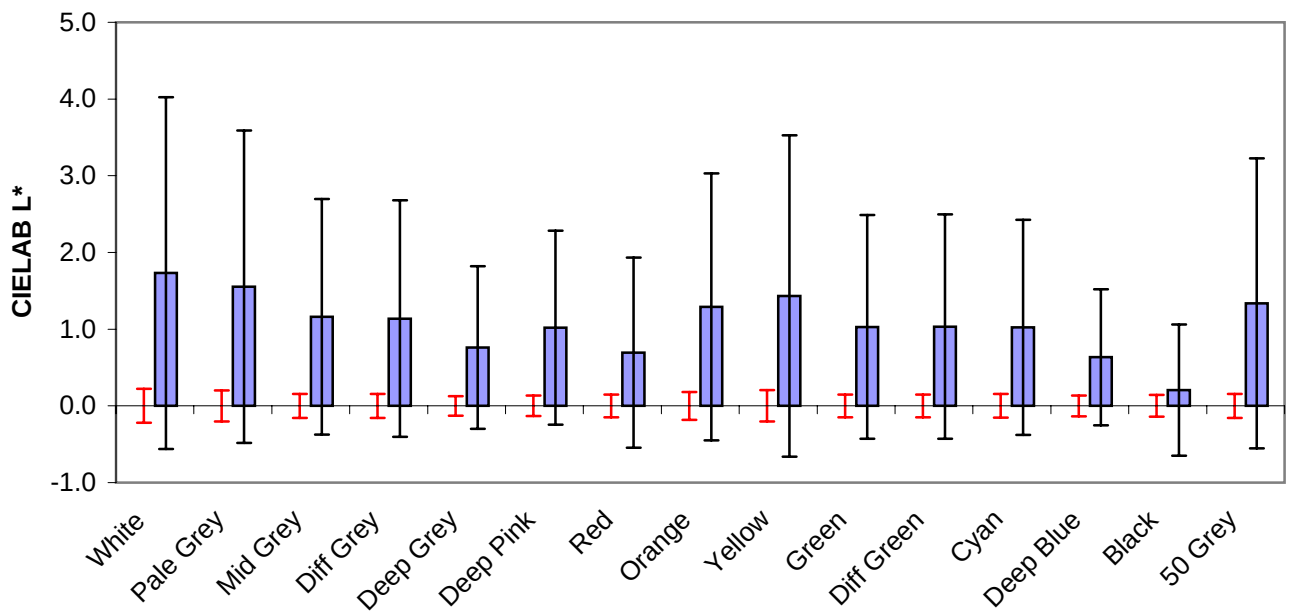
NPL Lambda Uncertainty

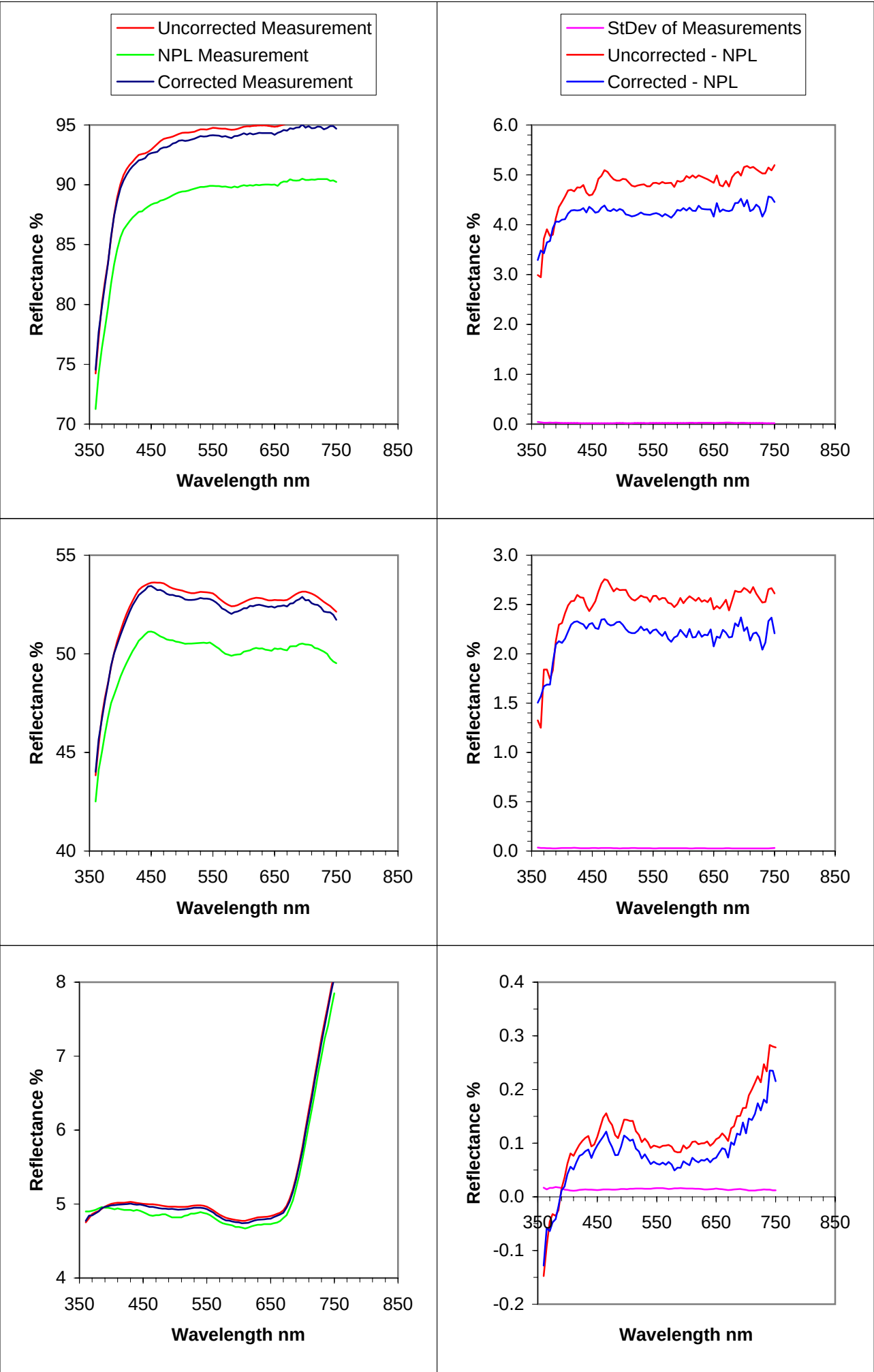
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.54	0.38	0.16	0.16	0.06	0.10	0.10	0.24	0.39	0.15	0.15	0.15	0.05	0.05	0.16
x	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004	0.0007	0.0002	0.0003	0.0003	0.0003	0.0001	0.0004	< 0.0001	< 0.0001
y	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	0.0001	0.0003	0.0001	0.0004	0.0004	0.0004	0.0005	< 0.0001	< 0.0001
L*	0.22	0.20	0.16	0.16	0.13	0.13	0.15	0.18	0.20	0.15	0.15	0.15	0.13	0.14	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.08	0.15	0.14	0.11	0.07	0.06	0.13	0.05	< 0.01	0.01
b*	< 0.01	0.01	0.01	< 0.01	< 0.01	0.10	0.13	0.18	0.18	0.13	0.12	0.12	0.10	< 0.01	0.01

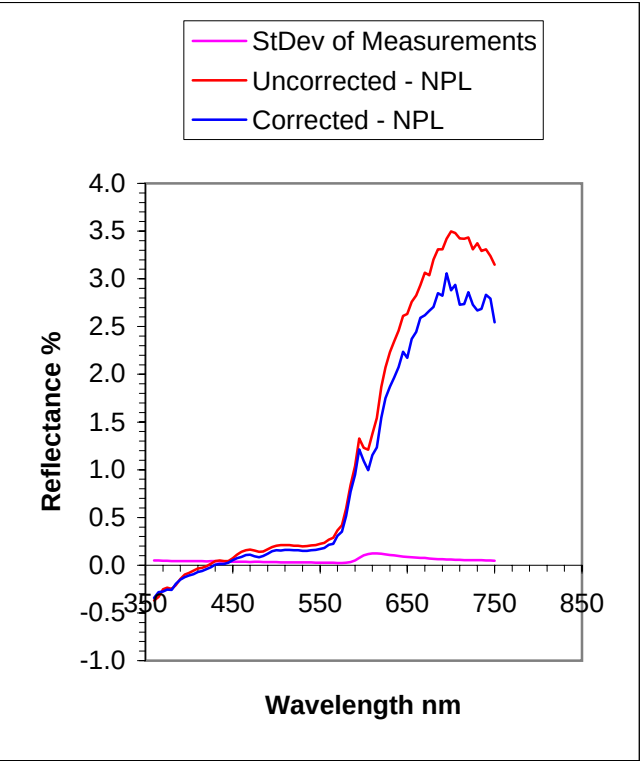
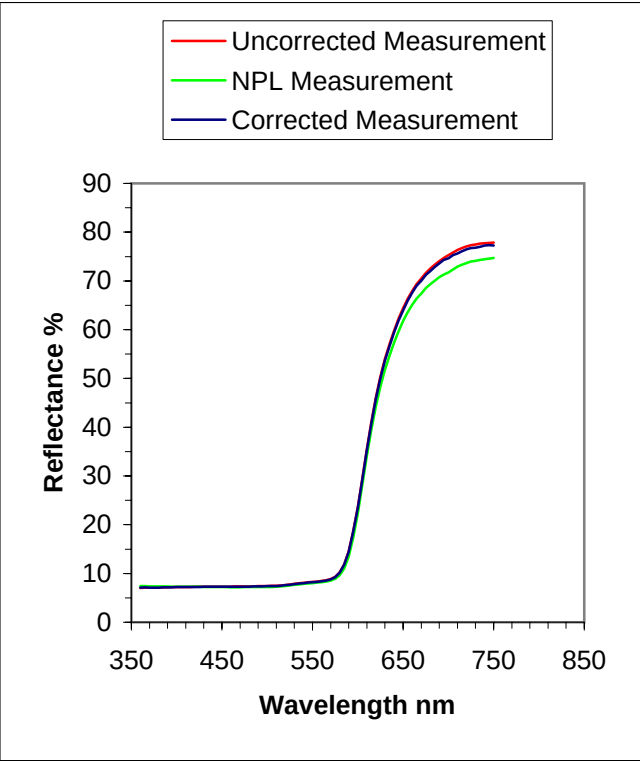
Colorimetry

			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	97.88	85.14	60.31	60.49	36.56	46.75	45.10	69.55	86.90	56.08	56.31	54.45	28.49	26.41	77.83
		a*	-0.30	-0.43	-0.38	-2.41	-0.30	25.46	42.96	37.71	-4.81	-29.94	-30.27	-10.59	9.15	-0.38	-0.13
		b*	1.01	0.26	0.09	2.00	0.40	4.72	21.68	54.40	77.73	12.19	14.93	-30.59	-17.83	-0.48	-0.51
Average Measurement (Uncorrected)	B	L*	97.88	85.09	60.28	60.48	36.60	46.72	45.04	69.50	86.88	56.06	56.27	54.42	28.50	26.46	77.81
		a*	-0.30	-0.43	-0.40	-2.41	-0.30	25.36	42.84	37.84	-4.75	-29.84	-30.15	-10.51	9.13	-0.38	-0.13
		b*	1.01	0.25	0.09	1.99	0.40	4.67	21.55	54.33	77.71	12.19	14.95	-30.58	-17.79	-0.48	-0.51
Average Measurement (Corrected)	C	L*	97.63	84.88	60.11	60.32	36.48	46.58	44.91	69.31	86.65	55.91	56.11	54.27	28.41	26.36	77.61
		a*	-0.26	-0.40	-0.38	-2.38	-0.29	25.32	42.75	37.76	-4.75	-29.77	-30.07	-10.44	9.14	-0.37	-0.10
		b*	0.95	0.19	0.04	1.95	0.37	4.62	21.48	54.18	77.52	12.14	14.90	-30.56	-17.80	-0.51	-0.57
NPL Values	D	L*	95.90	83.32	58.95	59.18	35.72	45.57	44.22	68.02	85.22	54.88	55.08	53.24	27.77	26.16	76.27
		a*	-0.33	-0.45	-0.40	-2.44	-0.29	25.24	42.07	37.47	-4.84	-29.78	-30.04	-10.57	9.20	-0.36	-0.09
		b*	1.02	0.27	0.11	2.07	0.38	4.58	20.50	53.35	76.68	12.17	14.97	-29.95	-17.66	-0.40	-0.50
A to B		dE*	0.009	0.048	0.037	0.012	0.034	0.116	0.185	0.147	0.068	0.101	0.133	0.084	0.045	0.050	0.027
B to C		dE*	0.258	0.229	0.173	0.175	0.119	0.151	0.177	0.254	0.290	0.181	0.183	0.169	0.097	0.096	0.212
B to D		dE*	1.979	1.774	1.328	1.306	0.876	1.164	1.540	1.815	1.947	1.186	1.195	1.334	0.746	0.309	1.540
C to D		dE*	1.735	1.557	1.165	1.146	0.762	1.022	1.374	1.565	1.661	1.029	1.037	1.199	0.652	0.232	1.338
Corrected + Uncertainty	E	L*	99.93	86.91	61.65	61.86	37.54	47.85	46.15	71.05	88.75	57.37	57.58	55.67	29.29	27.22	79.49
		a*	0.92	0.66	0.41	-1.57	0.24	25.42	43.43	38.37	-4.48	-28.61	-28.96	-8.71	9.87	0.05	0.90
		b*	3.24	2.22	1.55	3.47	1.38	5.98	22.84	56.33	79.84	13.42	16.20	-29.47	-16.92	0.26	1.31
Corrected - Uncertainty	F	L*	95.34	82.84	58.58	58.77	35.42	45.32	43.67	67.57	84.56	54.45	54.65	52.87	27.52	25.51	75.72
		a*	-1.44	-1.46	-1.17	-3.20	-0.81	25.22	42.07	37.15	-5.01	-30.92	-31.19	-12.17	8.41	-0.79	-1.09
		b*	-1.35	-1.83	-1.47	0.42	-0.64	3.27	20.12	52.04	75.21	10.85	13.59	-31.66	-18.68	-1.27	-2.44

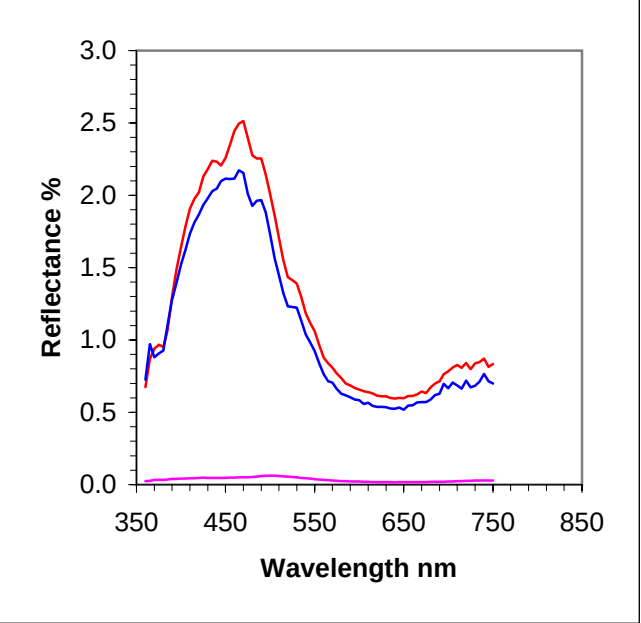
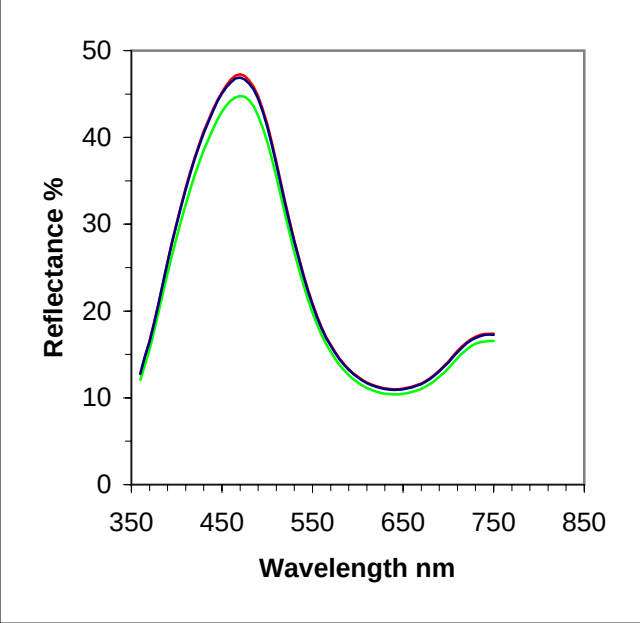




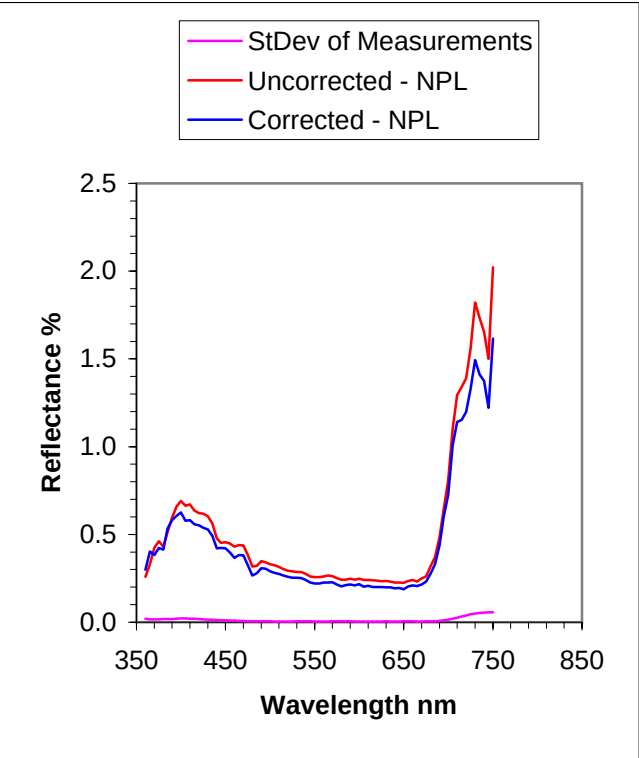
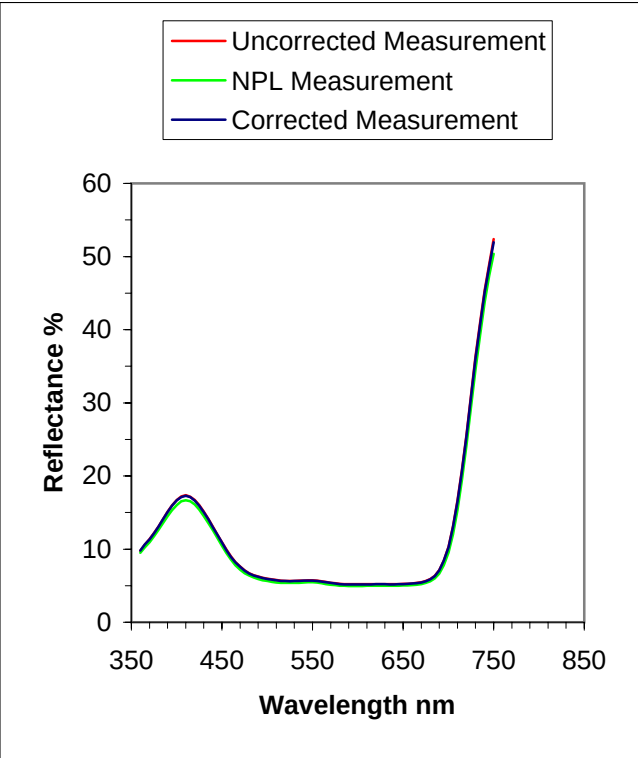




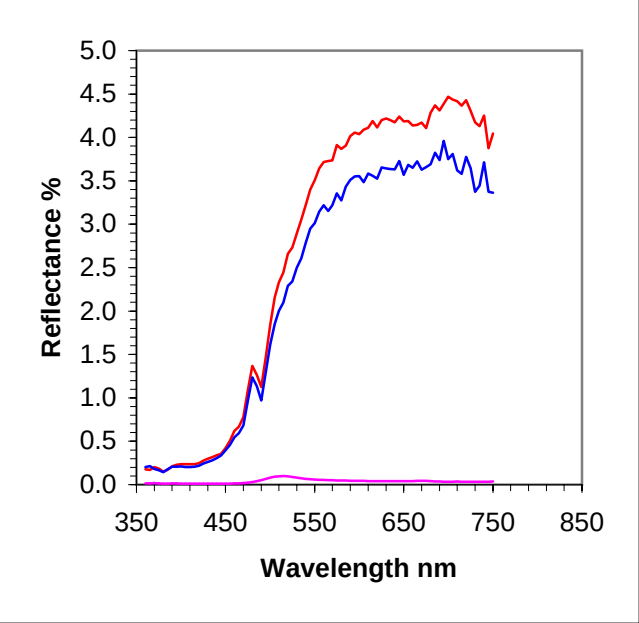
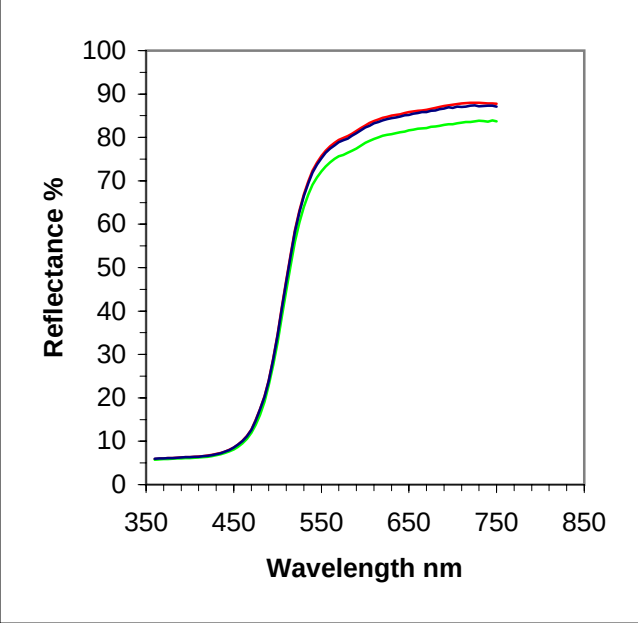
**Red
Gloss**



**Cyan
Gloss**



Blue
Gloss



Yellow
Gloss

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 3 mm (Small)

Geometry: SPIN

Tiles: Gloss

NPL Master Tiles: Colours Set ½

White WT53

Black BT03

Grey GT51

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0177	R%	+	0.5301	
450 nm	Uncert =	0.0174	R%	+	0.3541	
500 nm	Uncert =	0.0224	R%	+	0.4036	
550 nm	Uncert =	0.0214	R%	+	0.4226	
600 nm	Uncert =	0.0219	R%	+	0.5346	
650 nm	Uncert =	0.0198	R%	+	0.6315	
700 nm	Uncert =	0.0216	R%	+	0.7828	
<= 460 nm	Uncert =	0.020	R%	+	0.600	(k = 2)
>= 465 nm	Uncert =	0.025	R%	+	0.800	(k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	1.44	2.85
a*	0.27	1.26
b*	0.35	1.79

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0129	R%	+	0.5524	
450 nm	Uncert =	0.0136	R%	+	0.3712	
500 nm	Uncert =	0.0148	R%	+	0.4024	
550 nm	Uncert =	0.0140	R%	+	0.4186	
600 nm	Uncert =	0.0155	R%	+	0.5196	
650 nm	Uncert =	0.0121	R%	+	0.5980	
700 nm	Uncert =	0.0126	R%	+	0.7493	
<= 460 nm	Uncert =	0.014	R%	+	0.600	(k = 2)
>= 460 nm	Uncert =	0.016	R%	+	0.800	(k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	1.22	2.72
a*	0.24	1.27
b*	0.26	1.77

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	3.07	2.40	1.48	1.49	1.02	1.18	1.14	1.73	2.41	1.37	1.38	1.33	0.93	0.92	2.08
x	0.0003	0.0004	0.0006	0.0005	0.0011	0.0030	0.0095	0.0042	0.0018	0.0019	0.0017	0.0032	0.0070	0.0025	0.0004
y	0.0006	0.0007	0.0011	0.0009	0.0024	0.0024	0.0016	0.0009	0.0020	0.0016	0.0020	0.0033	0.0132	0.0047	0.0008
L*	1.28	1.26	1.38	1.38	2.05	1.64	1.70	1.31	1.27	1.44	1.44	1.47	2.67	2.85	1.27
a*	0.15	0.16	0.18	0.15	0.27	0.79	1.16	0.27	0.17	0.40	0.41	0.09	1.26	0.39	0.16
b*	0.30	0.30	0.35	0.33	0.52	0.32	0.48	0.65	0.50	0.15	0.09	0.62	1.79	0.80	0.31

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

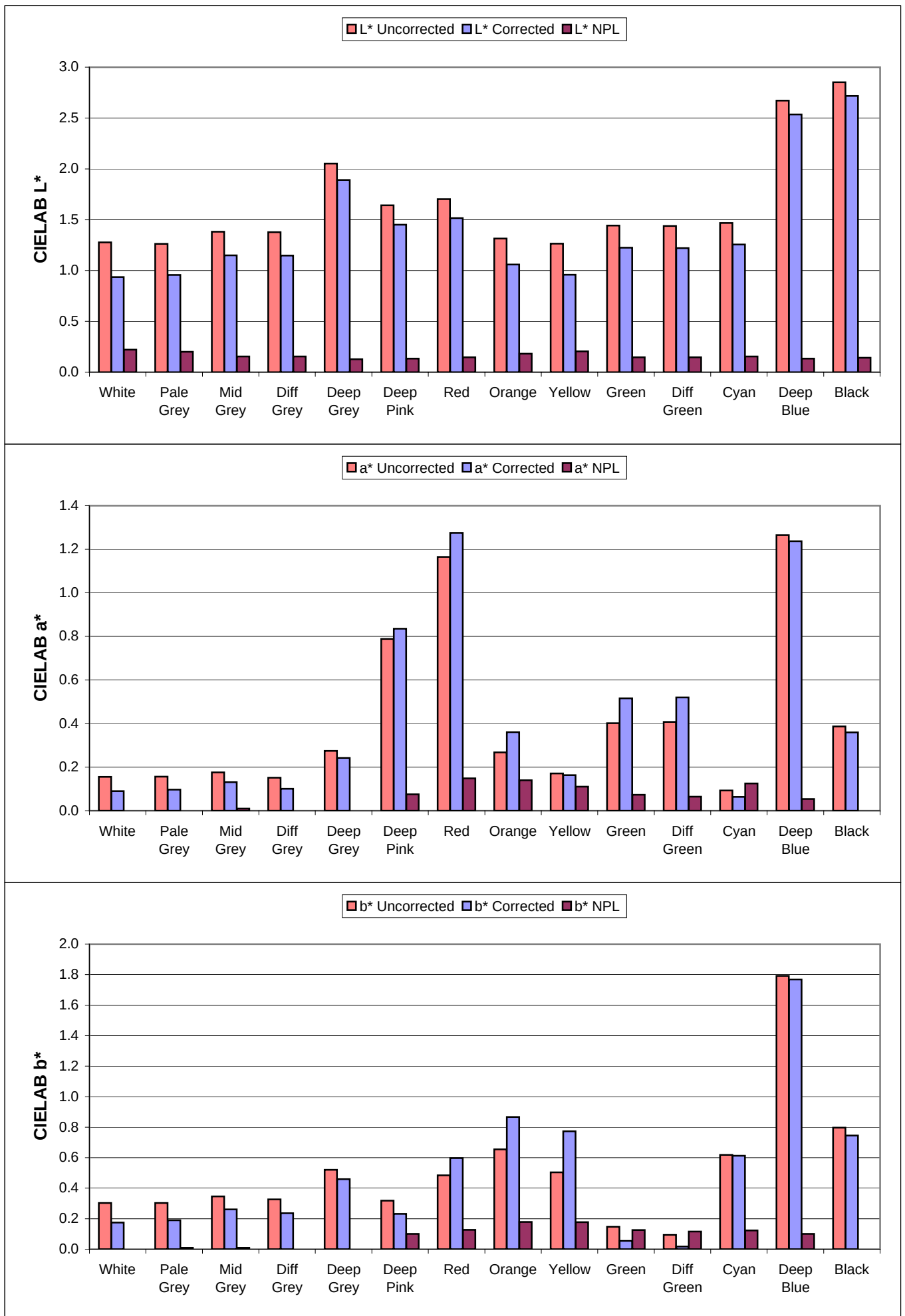
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	2.24	1.82	1.23	1.24	0.94	1.04	1.02	1.39	1.83	1.16	1.17	1.14	0.88	0.87	1.61
x	0.0002	0.0002	0.0004	0.0004	0.0010	0.0032	0.0096	0.0043	0.0019	0.0019	0.0016	0.0031	0.0068	0.0023	0.0003
y	0.0004	0.0005	0.0008	0.0006	0.0021	0.0021	0.0014	0.0010	0.0020	0.0018	0.0023	0.0030	0.0128	0.0044	0.0006
L*	0.93	0.96	1.15	1.15	1.89	1.45	1.52	1.06	0.96	1.22	1.22	1.26	2.53	2.72	0.99
a*	0.09	0.10	0.13	0.10	0.24	0.83	1.27	0.36	0.16	0.52	0.52	0.06	1.24	0.36	0.11
b*	0.17	0.19	0.26	0.24	0.46	0.23	0.60	0.87	0.77	0.05	0.02	0.61	1.77	0.75	0.21

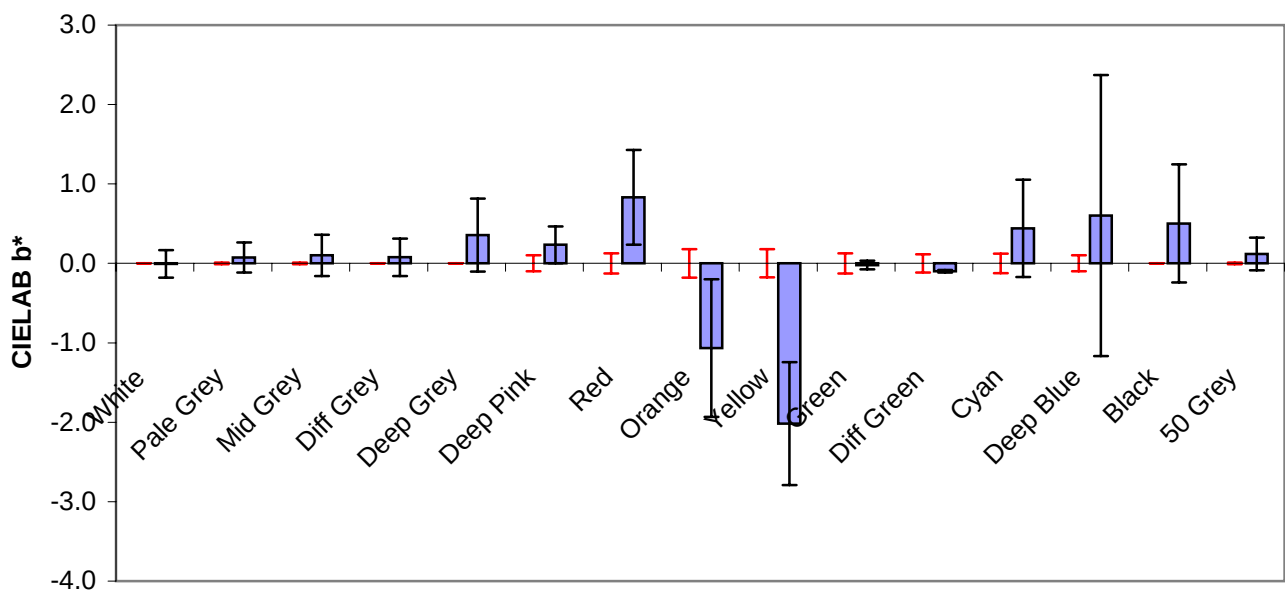
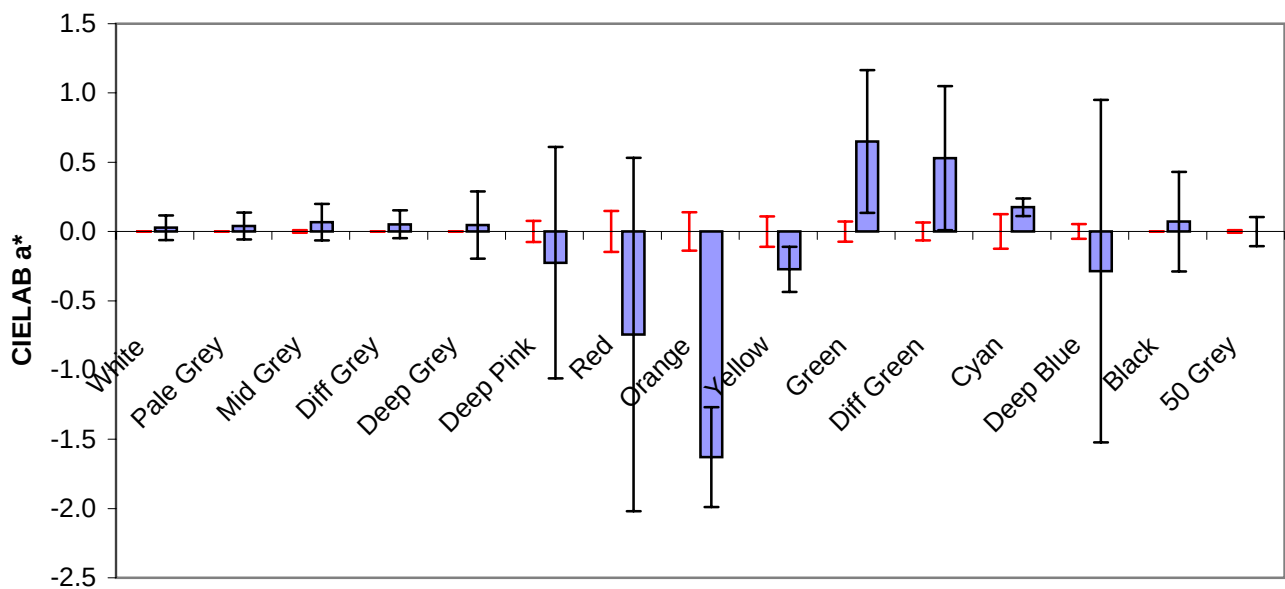
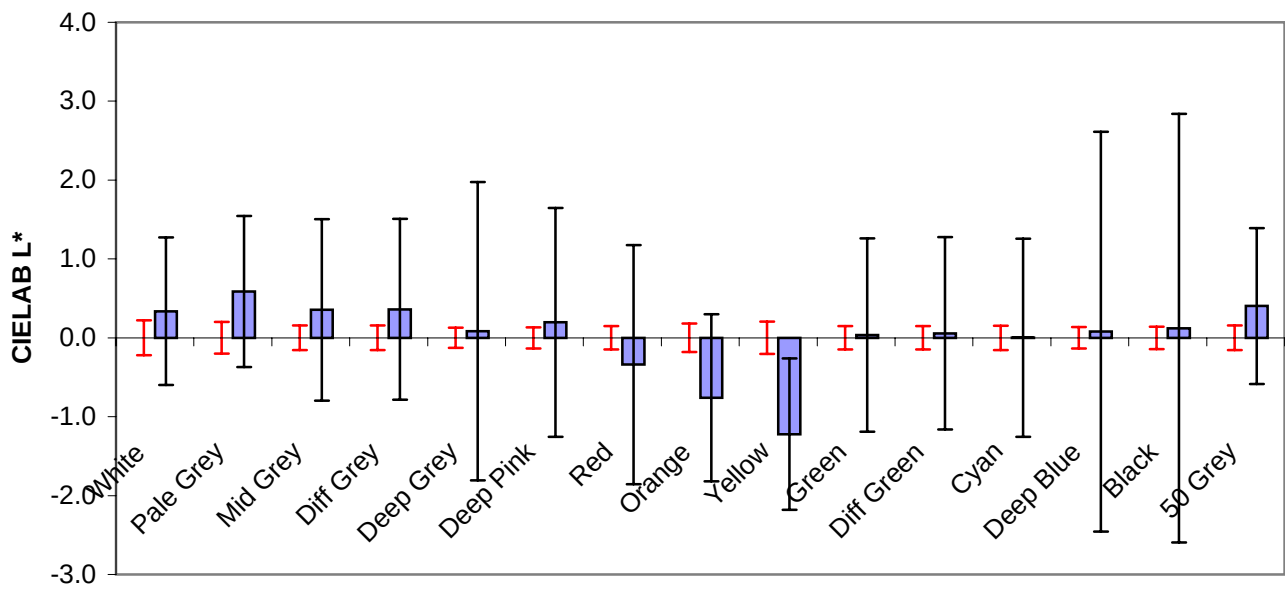
NPL Lambda Uncertainty

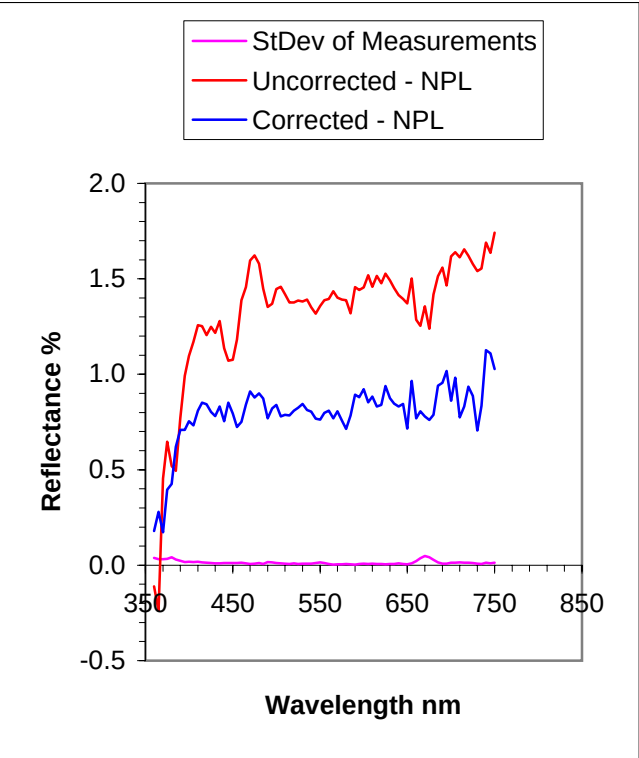
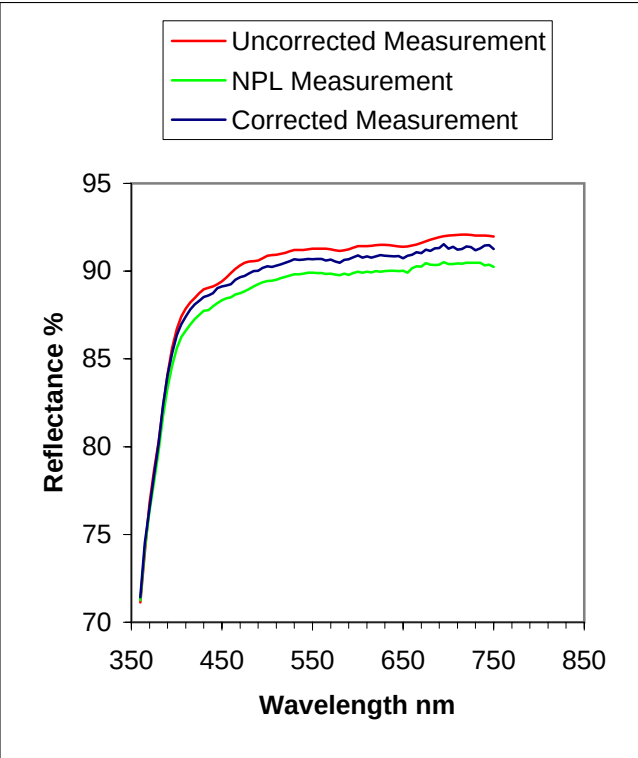
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.54	0.38	0.16	0.16	0.06	0.10	0.10	0.24	0.39	0.15	0.15	0.15	0.05	0.05	0.16
x	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004	0.0007	0.0002	0.0003	0.0003	0.0003	0.0001	0.0004	< 0.0001	< 0.0001
y	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	0.0001	0.0003	0.0001	0.0004	0.0004	0.0004	0.0005	< 0.0001	< 0.0001
L*	0.22	0.20	0.16	0.16	0.13	0.13	0.15	0.18	0.20	0.15	0.15	0.15	0.13	0.14	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.08	0.15	0.14	0.11	0.07	0.06	0.13	0.05	< 0.01	0.01
b*	< 0.01	0.01	0.01	< 0.01	< 0.01	0.10	0.13	0.18	0.18	0.13	0.12	0.12	0.10	< 0.01	0.01

Colorimetry

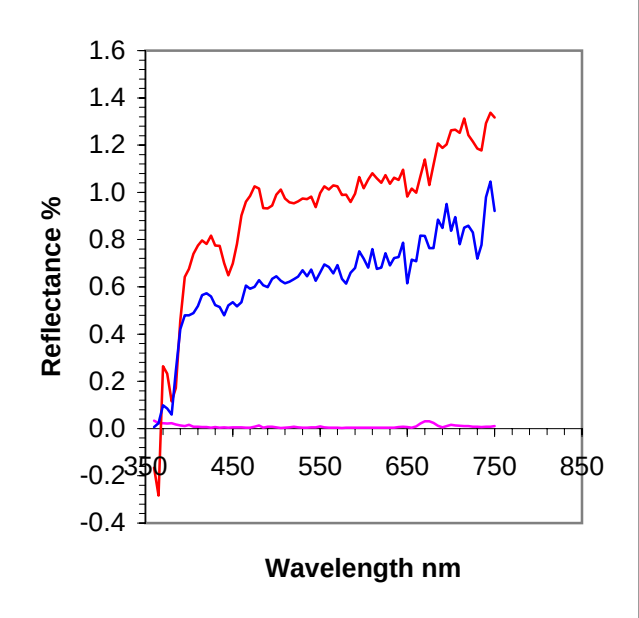
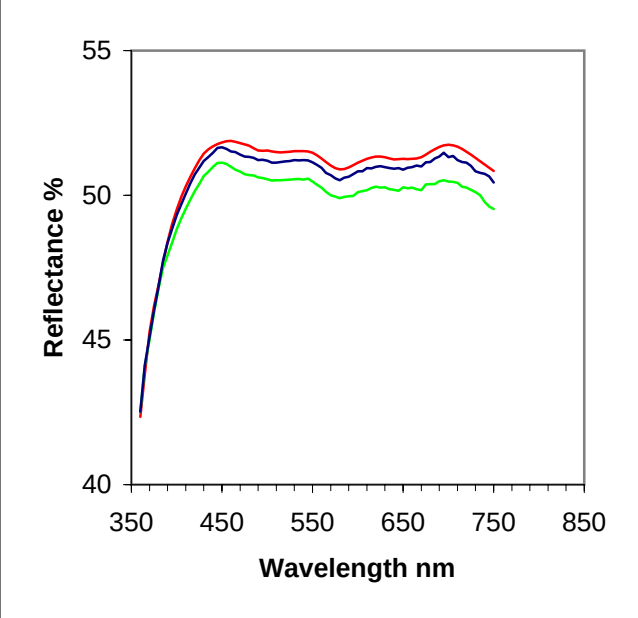
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	96.49	84.13	59.46	59.70	35.91	45.90	44.03	67.47	84.25	55.08	55.30	53.40	27.94	26.36	76.87
		a*	-0.34	-0.44	-0.35	-2.40	-0.26	25.08	41.45	35.89	-5.16	-29.25	-29.63	-10.49	8.91	-0.30	-0.12
		b*	1.08	0.41	0.25	2.19	0.77	4.88	21.45	52.47	74.89	12.20	14.93	-29.53	-17.06	0.12	-0.33
Average Measurement (Uncorrected)	B	L*	96.48	84.13	59.47	59.70	35.92	45.90	44.01	67.45	84.22	55.07	55.29	53.40	27.95	26.37	76.87
		a*	-0.34	-0.44	-0.36	-2.41	-0.26	25.06	41.41	35.91	-5.12	-29.20	-29.58	-10.47	8.90	-0.30	-0.12
		b*	1.08	0.40	0.26	2.19	0.77	4.87	21.41	52.43	74.85	12.20	14.92	-29.53	-17.06	0.13	-0.33
Average Measurement (Corrected)	C	L*	96.24	83.91	59.30	59.54	35.80	45.76	43.88	67.26	84.00	54.92	55.14	53.25	27.85	26.28	76.67
		a*	-0.31	-0.41	-0.34	-2.38	-0.25	25.02	41.33	35.84	-5.11	-29.13	-29.51	-10.40	8.91	-0.29	-0.09
		b*	1.01	0.34	0.22	2.15	0.74	4.82	21.33	52.28	74.67	12.15	14.87	-29.51	-17.06	0.10	-0.39
NPL Values	D	L*	95.90	83.32	58.95	59.18	35.72	45.57	44.22	68.02	85.22	54.88	55.08	53.24	27.77	26.16	76.27
		a*	-0.33	-0.45	-0.40	-2.44	-0.29	25.24	42.07	37.47	-4.84	-29.78	-30.04	-10.57	9.20	-0.36	-0.09
		b*	1.02	0.27	0.11	2.07	0.38	4.58	20.50	53.35	76.68	12.17	14.97	-29.95	-17.66	-0.40	-0.50
A to B		dE*	0.008	0.013	0.016	0.007	0.004	0.024	0.058	0.054	0.072	0.050	0.052	0.024	0.008	0.018	0.001
B to C		dE*	0.255	0.227	0.171	0.173	0.118	0.149	0.173	0.246	0.282	0.179	0.180	0.166	0.096	0.096	0.210
B to D		dE*	0.584	0.817	0.540	0.540	0.437	0.475	1.141	1.897	2.111	0.604	0.504	0.465	0.697	0.573	0.629
C to D		dE*	0.338	0.594	0.375	0.373	0.370	0.380	1.167	2.090	2.372	0.650	0.542	0.476	0.670	0.522	0.420
Corrected + Uncertainty	E	L*	97.17	84.87	60.45	60.68	37.69	47.21	45.39	68.32	84.96	56.14	56.36	54.50	30.39	29.00	77.66
		a*	-0.22	-0.32	-0.21	-2.28	0.00	25.85	42.60	36.20	-4.95	-28.61	-28.99	-10.33	10.15	0.07	0.02
		b*	1.19	0.53	0.48	2.38	1.19	5.05	21.93	53.15	75.44	12.20	14.88	-28.90	-15.29	0.85	-0.18
Corrected - Uncertainty	F	L*	95.30	82.95	58.15	58.39	33.91	44.31	42.36	66.20	83.04	53.69	53.92	51.99	25.32	23.56	75.69
		a*	-0.40	-0.51	-0.47	-2.48	-0.49	24.18	40.06	35.48	-5.27	-29.64	-30.03	-10.46	7.68	-0.65	-0.20
		b*	0.84	0.15	-0.04	1.91	0.28	4.58	20.73	51.41	73.90	12.09	14.85	-30.12	-18.83	-0.64	-0.59



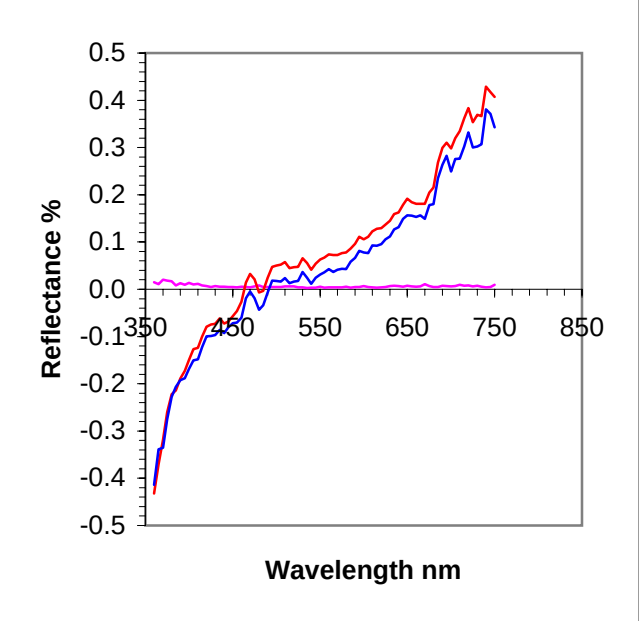
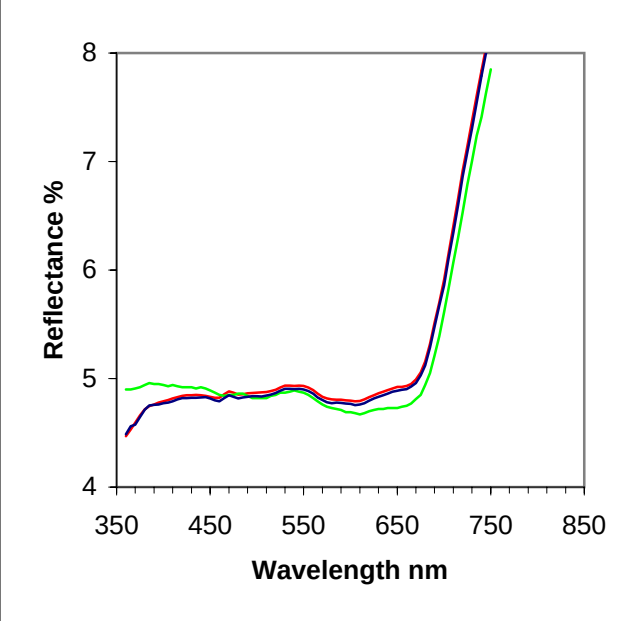




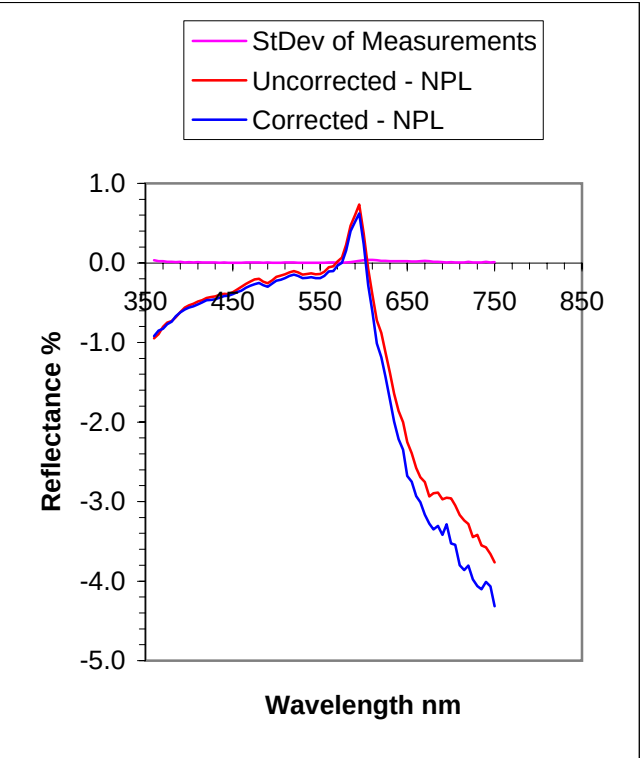
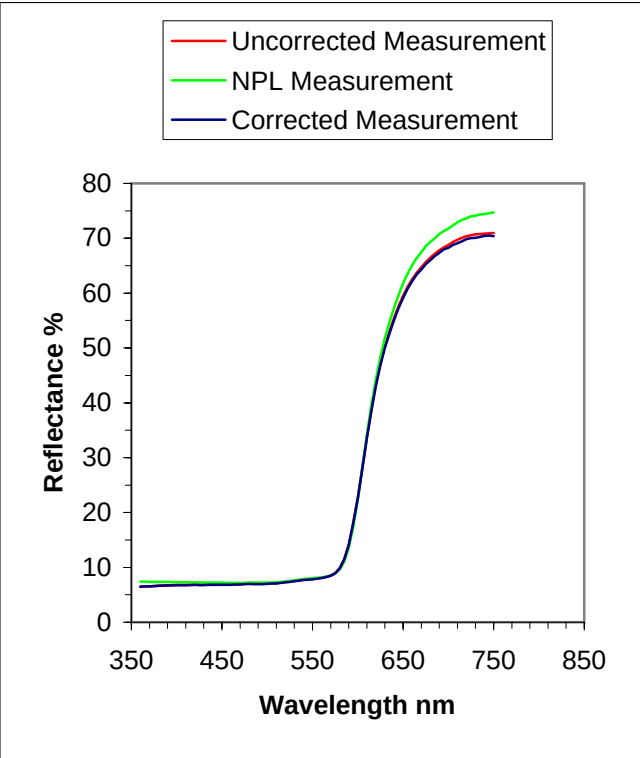
**White
Gloss**



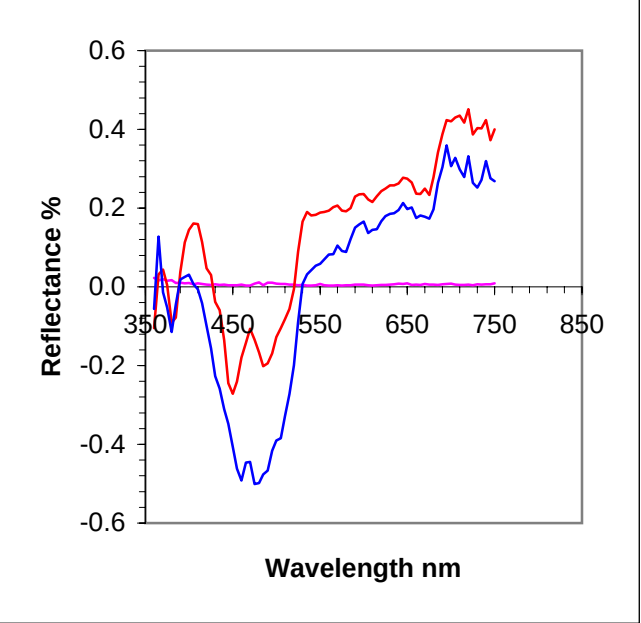
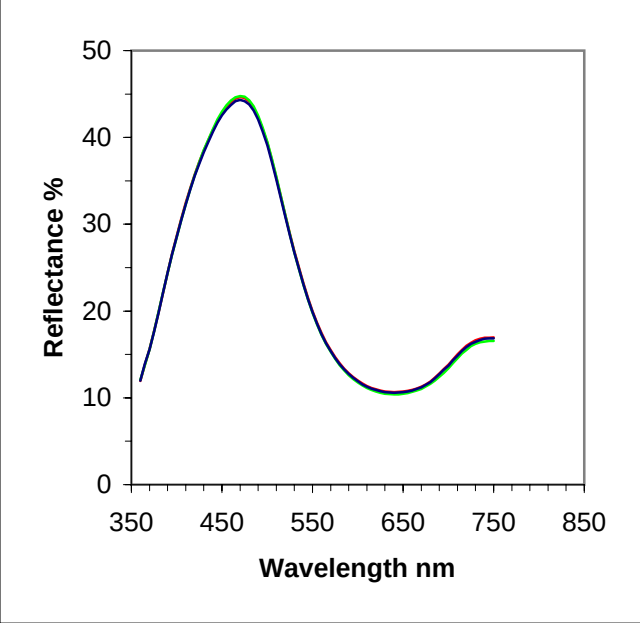
**50 Grey
Gloss**



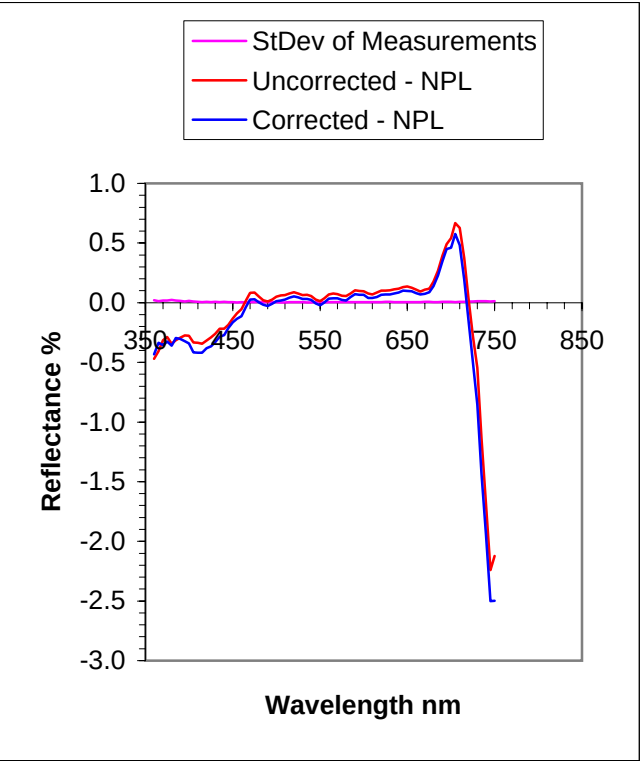
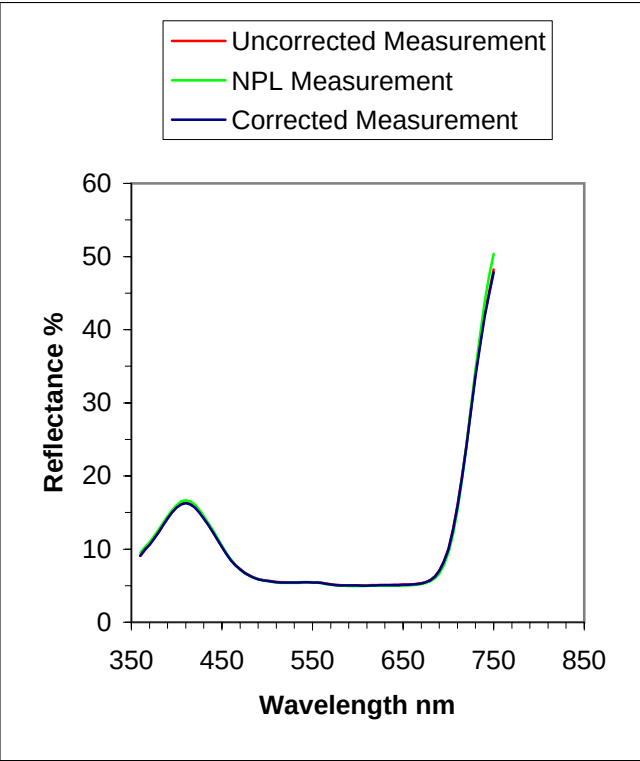
**Black
Gloss**



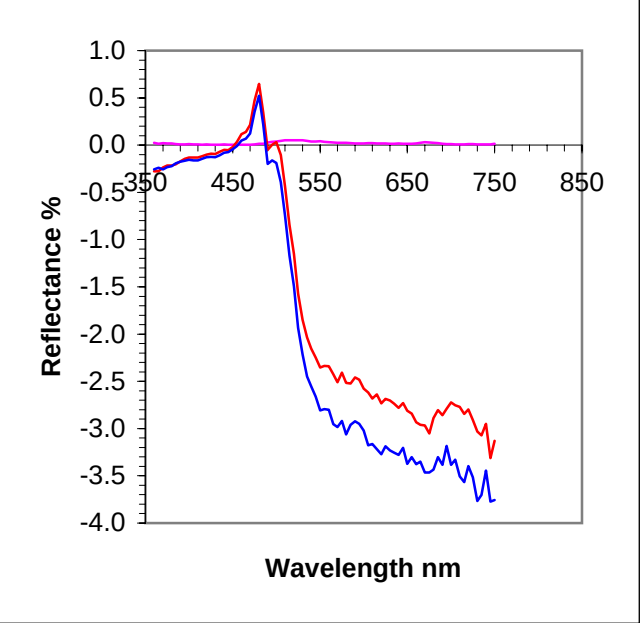
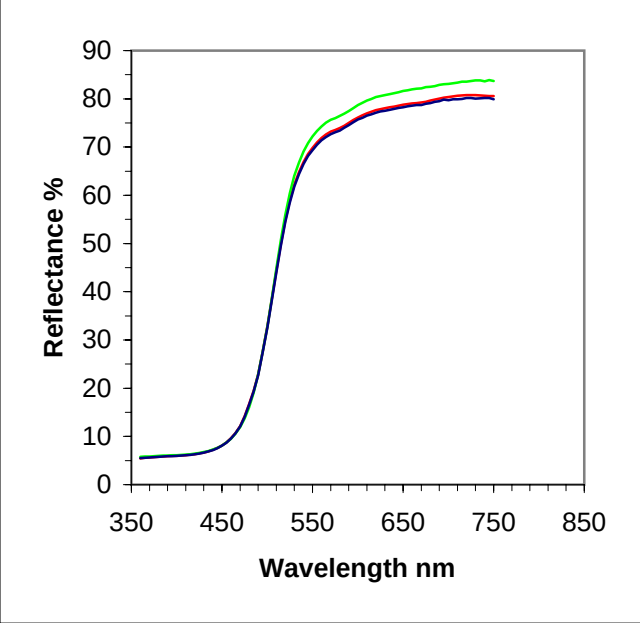
**Red
Gloss**



**Cyan
Gloss**



**Blue
Gloss**



**Yellow
Gloss**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 25 mm (Large)

Geometry: SPEX

Tiles: Gloss

NPL Master Tiles: Colours Set ½

White WT53

Black BT03

Grey GT51

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0090	R%	+	0.3146
450 nm	Uncert =	0.0064	R%	+	0.2080
500 nm	Uncert =	0.0096	R%	+	0.2120
550 nm	Uncert =	0.0082	R%	+	0.1965
600 nm	Uncert =	0.0086	R%	+	0.2404
650 nm	Uncert =	0.0088	R%	+	0.2567
700 nm	Uncert =	0.0110	R%	+	0.1679

<= 460 nm Uncert = **0.009** R% + **0.300** (k = 2)

>= 465 nm Uncert = **0.010** R% + **0.250** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	0.52	2.34
a*	0.11	2.95
b*	0.17	3.10

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0054	R%	+	0.2166
450 nm	Uncert =	0.0053	R%	+	0.2062
500 nm	Uncert =	0.0053	R%	+	0.2005
550 nm	Uncert =	0.0052	R%	+	0.2027
600 nm	Uncert =	0.0053	R%	+	0.2051
650 nm	Uncert =	0.0051	R%	+	0.2175
700 nm	Uncert =	0.0052	R%	+	0.1861

<= 460 nm Uncert = **0.0054** R% + **0.220** (k = 2)

>= 460 nm Uncert = **0.0054** R% + **0.220** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	0.38	2.02
a*	0.10	2.78
b*	0.09	2.33

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.11	0.84	0.48	0.48	0.30	0.36	0.34	0.61	0.89	0.44	0.44	0.42	0.26	0.25	0.72
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0006	0.0025	0.0106	0.0021	0.0009	0.0007	0.0006	0.0012	0.0115	0.1184	< 0.0001
y	< 0.0001	< 0.0001	0.0001	0.0002	0.0012	0.0002	0.0006	0.0009	0.0011	0.0019	0.0022	0.0009	0.0210	0.0602	< 0.0001
L*	0.48	0.46	0.50	0.50	0.91	0.61	0.69	0.48	0.47	0.52	0.52	0.53	2.34	2.29	0.46
a*	< 0.01	< 0.01	0.02	0.03	0.10	0.27	0.63	0.10	0.16	0.32	0.32	0.11	2.95	0.24	< 0.01
b*	0.02	< 0.01	0.03	0.04	0.19	0.17	3.10	0.78	0.52	0.17	0.22	0.10	2.48	0.50	< 0.01

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

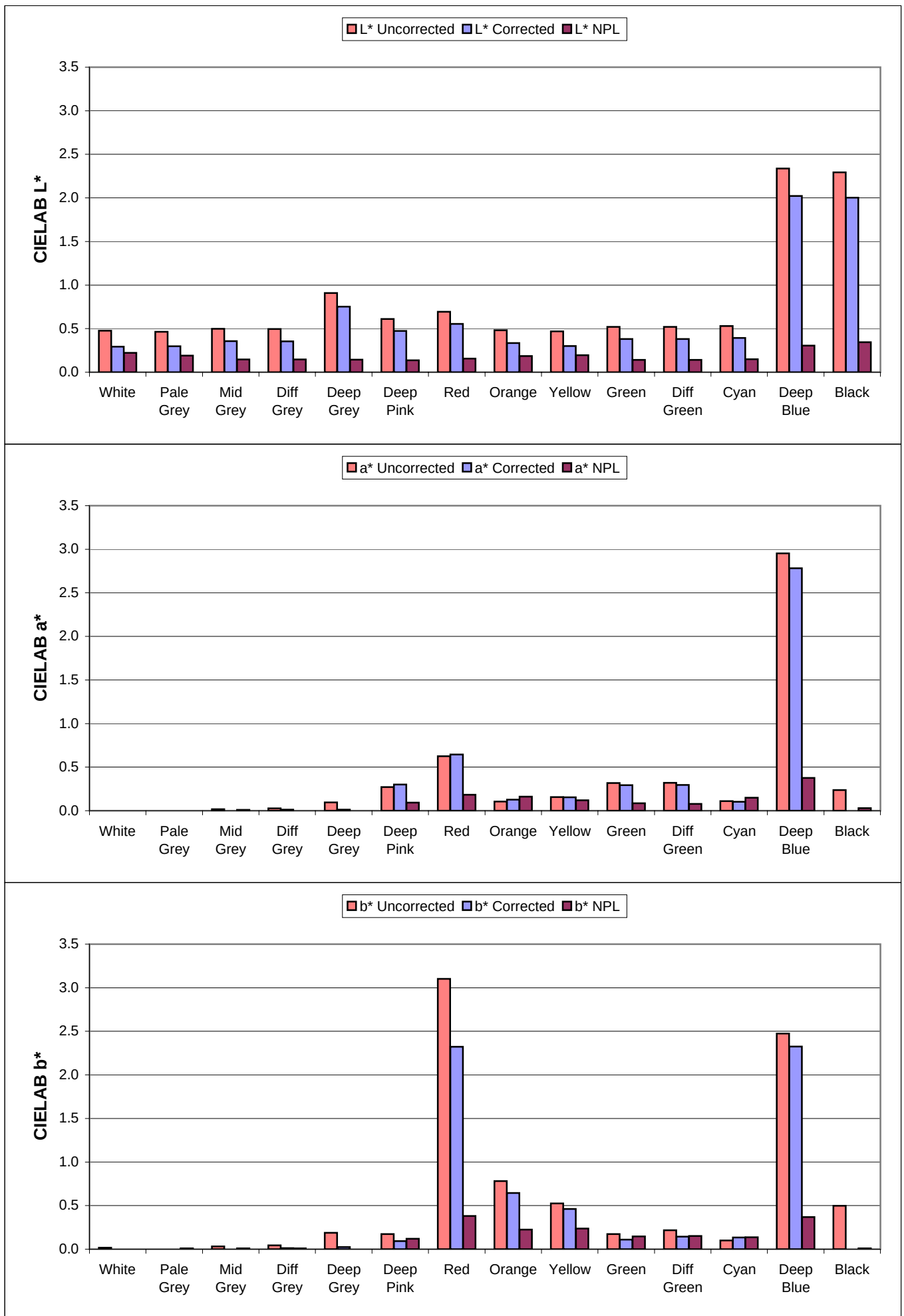
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.68	0.54	0.34	0.35	0.24	0.28	0.27	0.42	0.57	0.32	0.32	0.31	0.23	0.22	0.47
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	0.0020	0.0086	0.0017	0.0008	0.0007	0.0006	0.0011	0.0101	0.0764	< 0.0001
y	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	0.0004	0.0001	0.0007	0.0009	0.0014	0.0016	0.0009	0.0186	0.0024	< 0.0001
L*	0.29	0.30	0.36	0.36	0.75	0.47	0.55	0.33	0.30	0.38	0.38	0.39	2.02	2.00	0.30
a*	< 0.01	< 0.01	< 0.01	0.01	0.01	0.30	0.65	0.13	0.16	0.29	0.29	0.10	2.78	< 0.01	< 0.01
b*	< 0.01	< 0.01	< 0.01	0.01	0.02	0.09	2.32	0.64	0.46	0.11	0.14	0.14	2.33	< 0.01	< 0.01

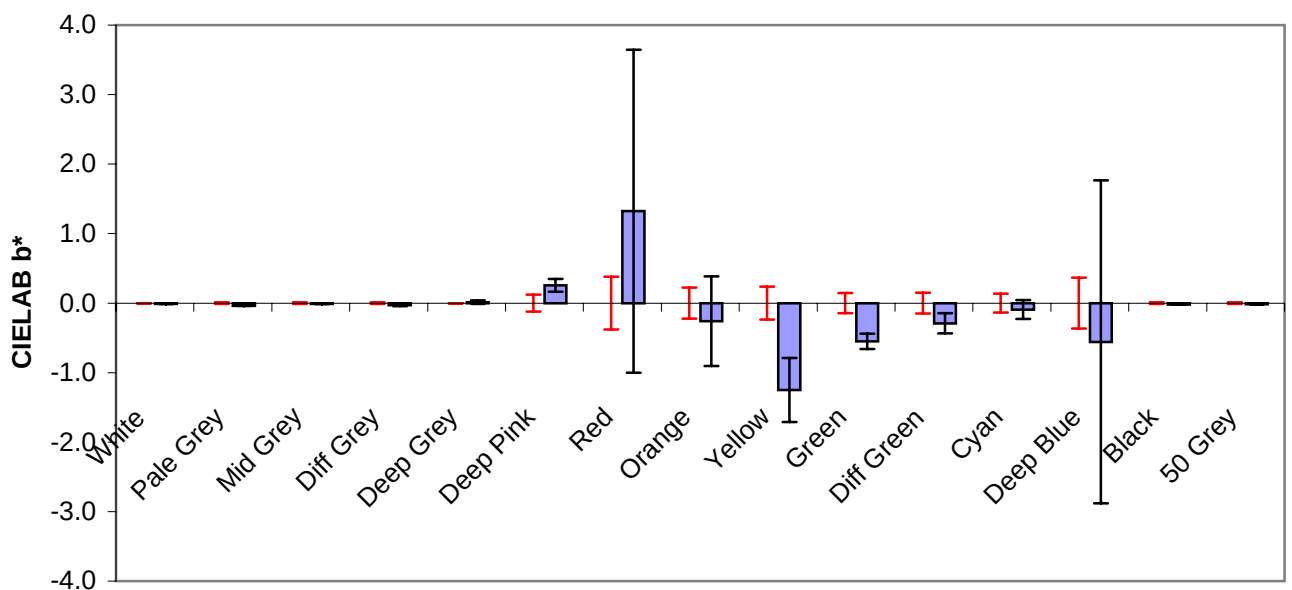
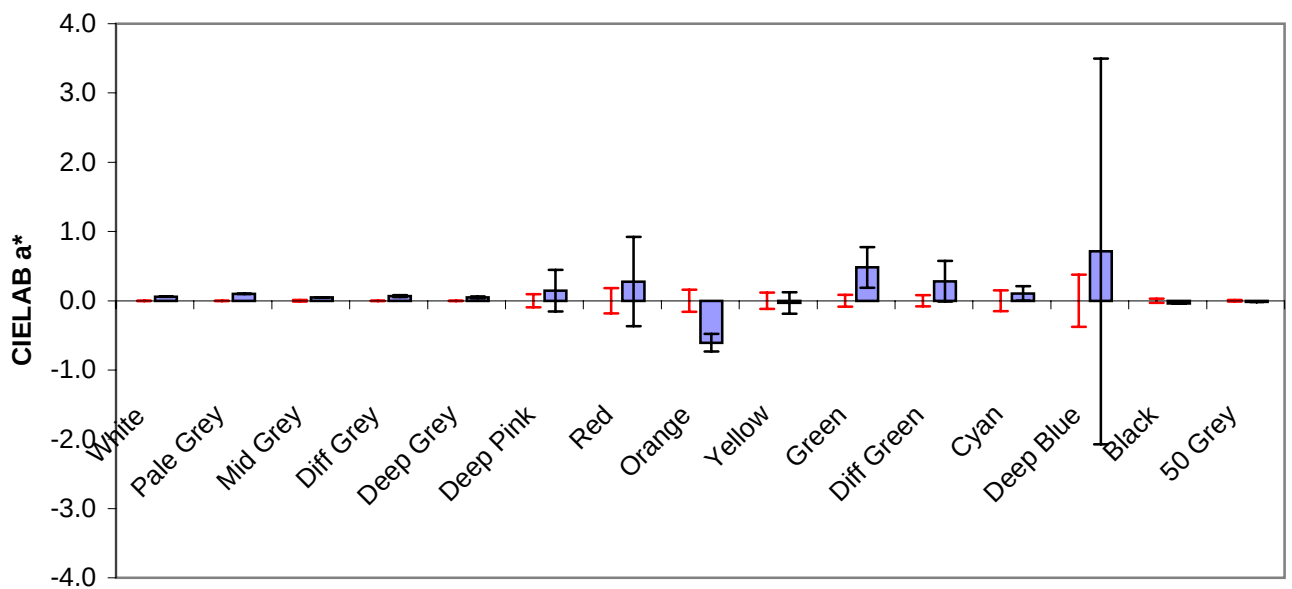
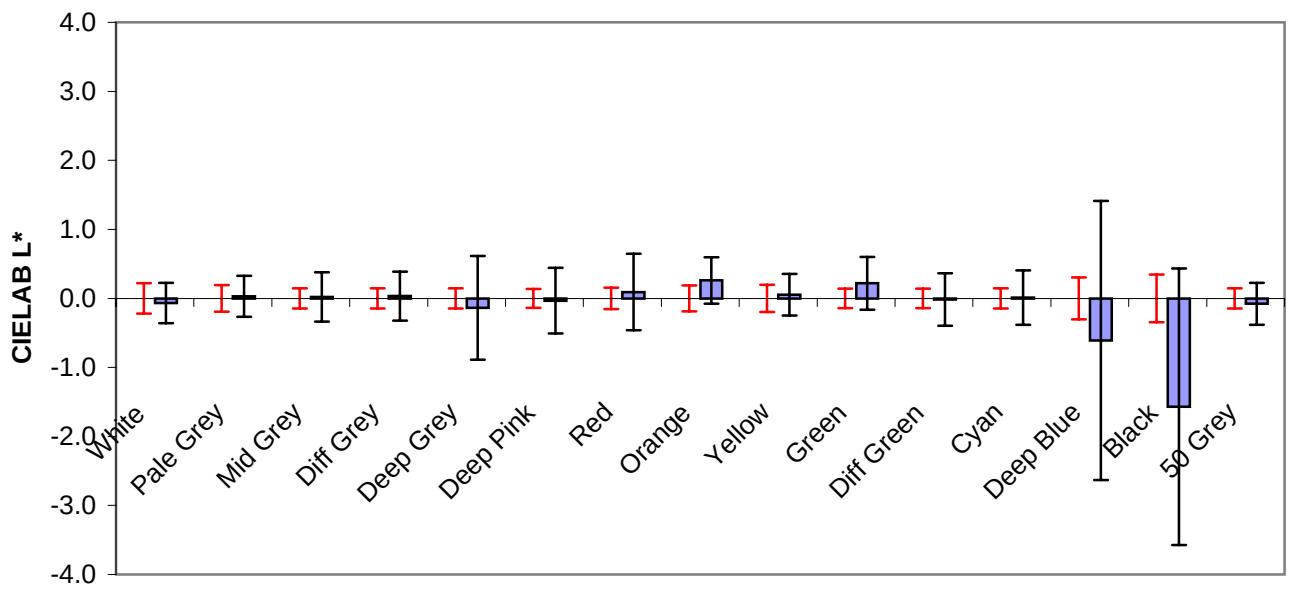
NPL Lambda Uncertainty

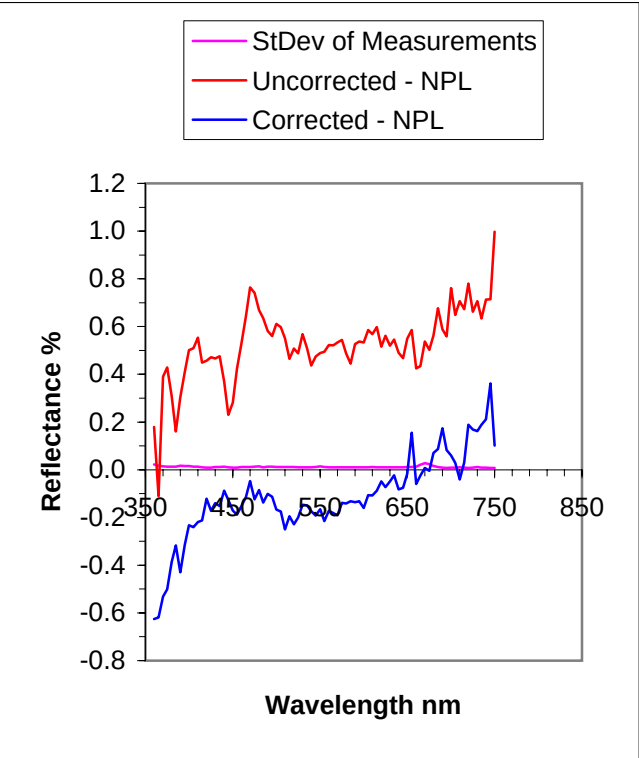
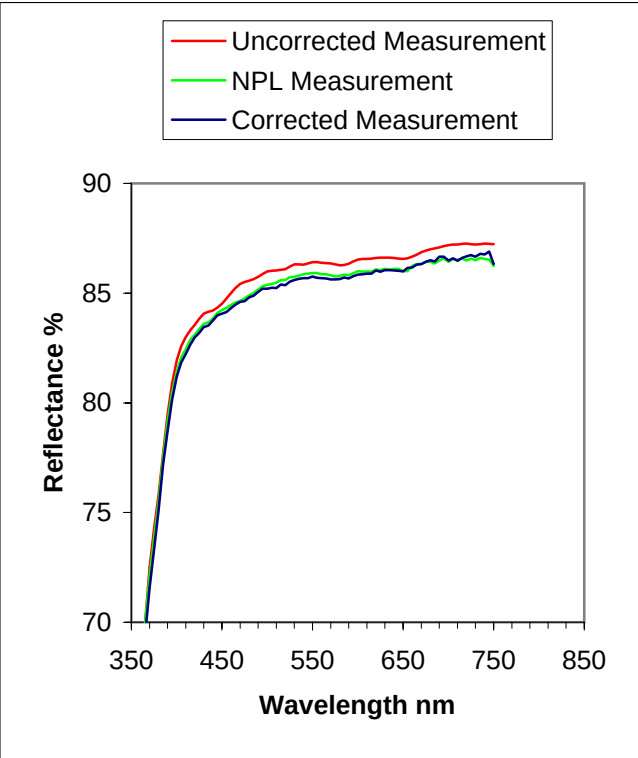
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.51	0.35	0.15	0.15	0.05	0.08	0.08	0.22	0.36	0.12	0.12	0.12	0.04	0.04	0.15
x	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	0.0006	0.0015	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	<0.0001
y	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	0.0001	0.0004	0.0001	0.0006	0.0006	0.0005	0.0027	0.0000	<0.0001
L*	0.22	0.19	0.15	0.15	0.14	0.14	0.16	0.19	0.20	0.14	0.14	0.15	0.30	0.34	0.15
a*	<0.01	<0.01	0.01	<0.01	<0.01	0.09	0.18	0.16	0.12	0.08	0.08	0.15	0.38	0.03	0.01
b*	<0.01	0.01	0.01	0.01	<0.01	0.12	0.4	0.23	0.24	0.15	0.15	0.14	0.37	0.01	0.01

Colorimetry

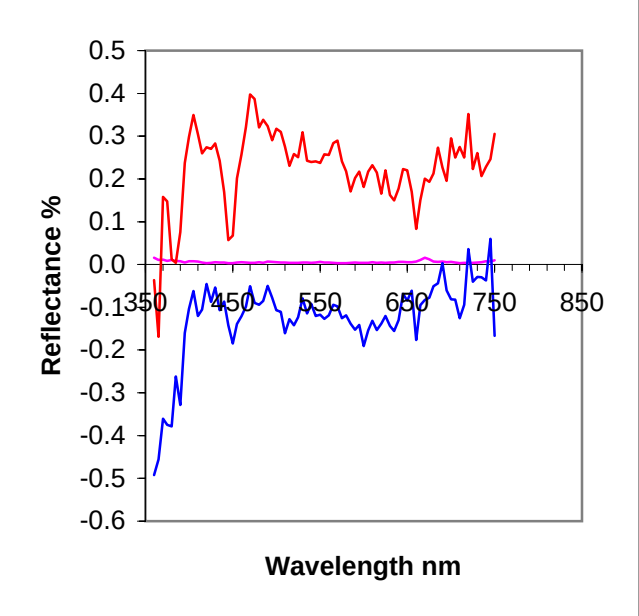
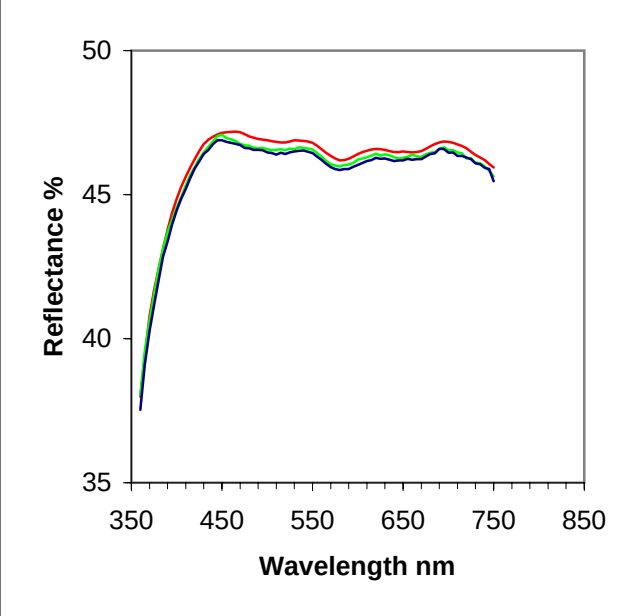
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	94.43	81.43	55.20	55.51	25.67	39.83	34.52	65.22	83.38	50.79	50.91	48.73	8.55	3.03	73.96
		a*	-0.34	-0.44	-0.48	-2.78	-0.44	30.09	55.43	39.69	-5.12	-34.30	-34.75	-12.25	24.36	-1.57	-0.19
		b*	1.14	0.35	0.19	2.37	0.79	6.02	42.41	64.05	85.77	13.89	17.54	-33.10	-34.11	-0.60	-0.37
Average Measurement (Uncorrected)	B	L*	94.43	81.43	55.20	55.51	25.67	39.82	34.53	65.22	83.34	50.75	50.89	48.73	8.54	3.02	73.96
		a*	-0.34	-0.44	-0.49	-2.77	-0.43	30.02	55.43	39.69	-5.03	-34.28	-34.68	-12.23	24.35	-1.57	-0.19
		b*	1.14	0.36	0.21	2.38	0.78	5.99	42.40	64.07	85.76	13.94	17.55	-33.10	-34.12	-0.60	-0.37
Average Measurement (Corrected)	C	L*	94.14	81.18	55.01	55.32	25.56	39.68	34.40	65.01	83.08	50.57	50.72	48.56	8.48	3.00	73.72
		a*	-0.27	-0.38	-0.44	-2.72	-0.41	29.98	55.31	39.62	-4.97	-34.15	-34.55	-12.14	24.32	-1.55	-0.14
		b*	1.11	0.34	0.19	2.36	0.77	5.96	42.30	63.91	85.54	13.90	17.50	-33.04	-34.05	-0.59	-0.39
NPL Values	D	L*	94.21	81.15	54.99	55.29	25.69	39.71	34.31	64.75	83.03	50.35	50.73	48.55	9.09	4.57	73.80
		a*	-0.32	-0.48	-0.49	-2.79	-0.46	29.84	55.04	40.23	-4.94	-34.63	-34.84	-12.25	23.61	-1.51	-0.12
		b*	1.12	0.38	0.20	2.39	0.76	5.70	40.98	64.17	86.80	14.45	17.79	-32.95	-33.50	-0.58	-0.37
A to B		dE*	0.003	0.011	0.015	0.016	0.006	0.074	0.014	0.024	0.097	0.070	0.074	0.022	0.012	0.009	0.003
B to C		dE*	0.298	0.263	0.193	0.195	0.113	0.149	0.194	0.275	0.338	0.222	0.224	0.205	0.098	0.030	0.243
B to D		dE*	0.224	0.290	0.206	0.221	0.043	0.354	1.489	0.716	1.089	0.735	0.327	0.242	1.112	1.549	0.174
C to D		dE*	0.088	0.110	0.055	0.081	0.146	0.297	1.354	0.709	1.253	0.763	0.405	0.142	1.090	1.572	0.081
Corrected + Uncertainty	E	L*	94.44	81.48	55.37	55.67	26.31	40.15	34.96	65.34	83.38	50.95	51.10	48.95	10.50	5.00	74.03
		a*	-0.27	-0.38	-0.44	-2.71	-0.39	30.28	55.96	39.75	-4.82	-33.86	-34.26	-12.04	27.10	-1.54	-0.13
		b*	1.11	0.34	0.19	2.37	0.80	6.05	44.62	64.55	86.01	14.01	17.64	-32.91	-31.73	-0.59	-0.38
Corrected - Uncertainty	F	L*	93.85	80.88	54.65	54.96	24.81	39.20	33.85	64.68	82.78	50.19	50.34	48.17	6.45	0.99	73.42
		a*	-0.27	-0.38	-0.44	-2.73	-0.42	29.68	54.67	39.49	-5.13	-34.45	-34.85	-12.24	21.54	-1.56	-0.14
		b*	1.11	0.33	0.19	2.35	0.75	5.87	39.97	63.26	85.08	13.79	17.35	-33.18	-36.38	-0.60	-0.39



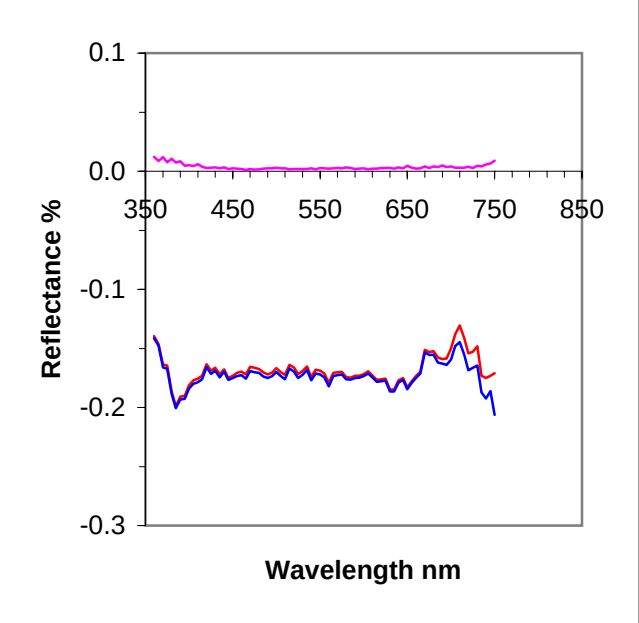
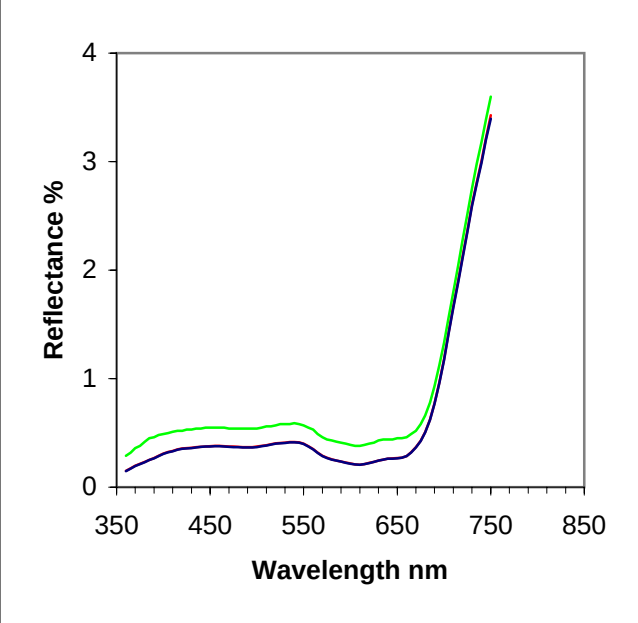




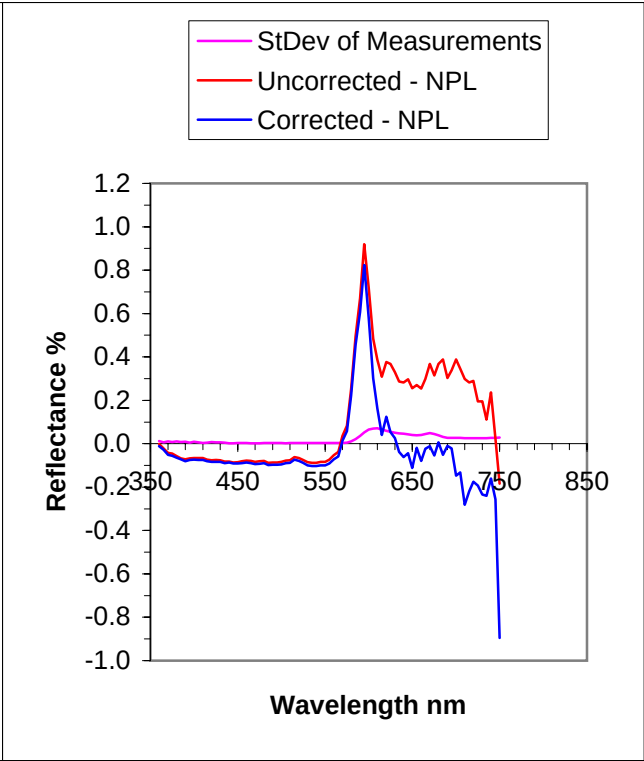
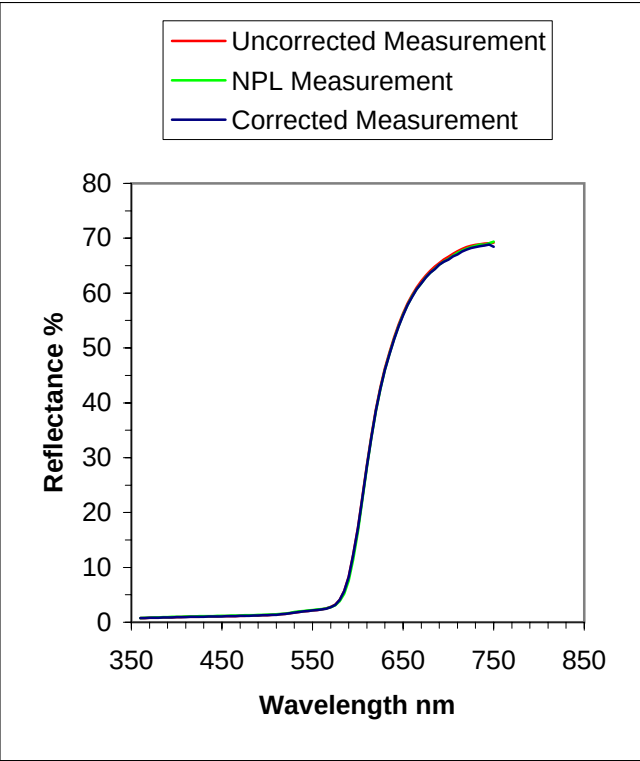
White Gloss



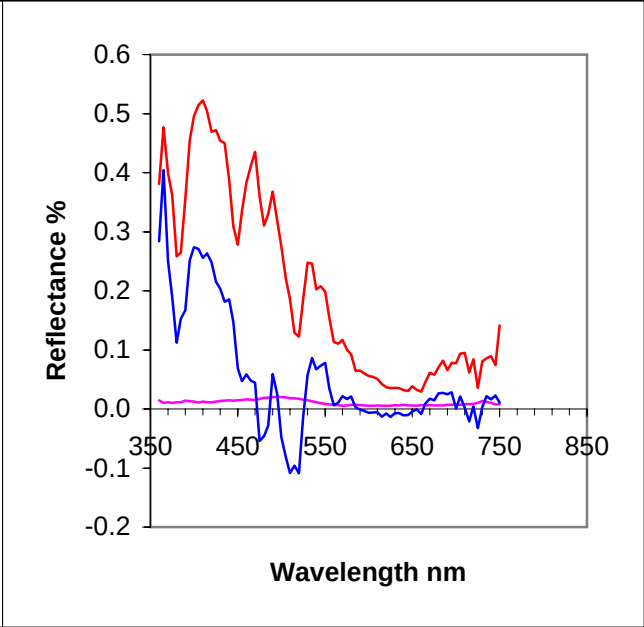
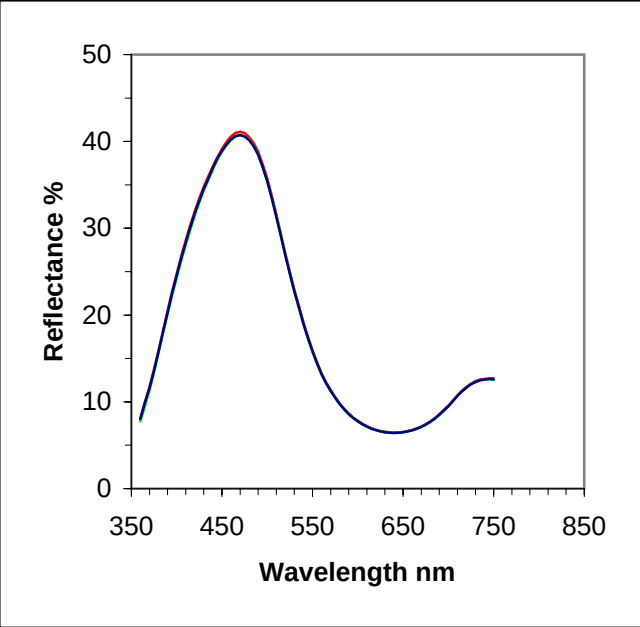
50 Grey Gloss



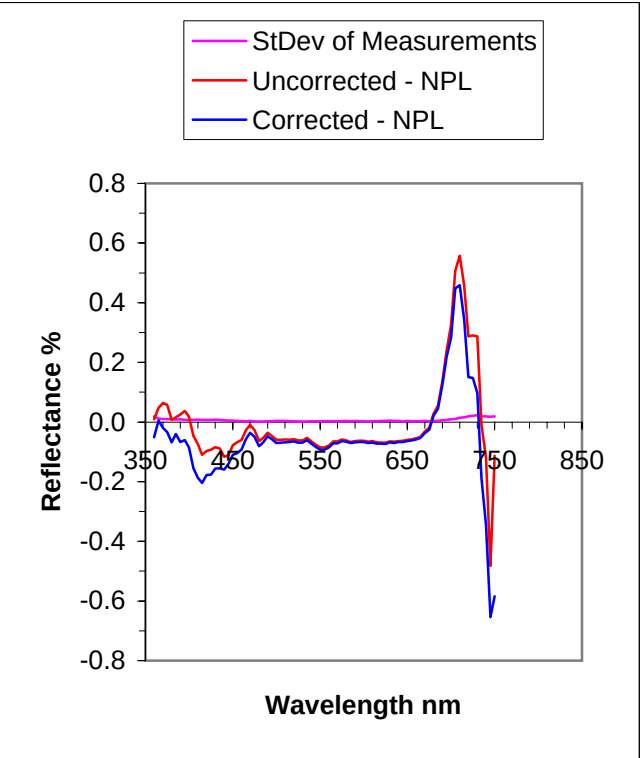
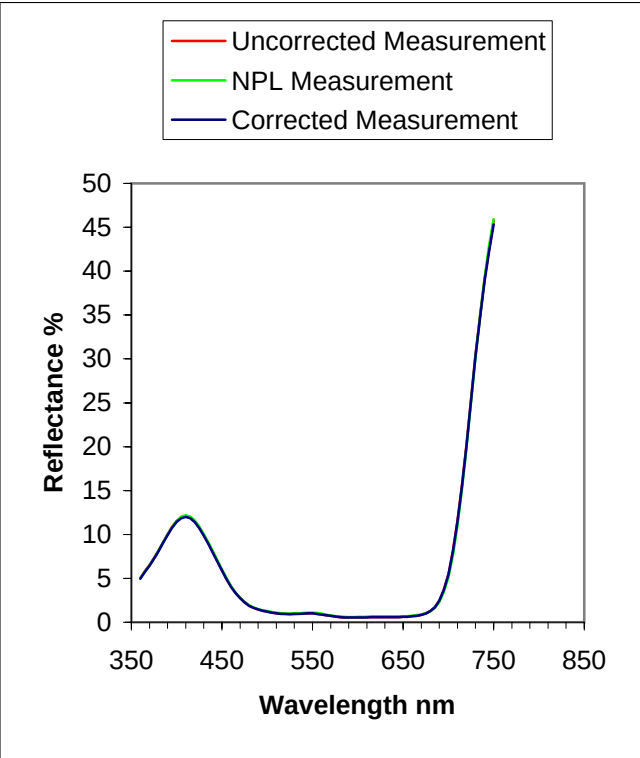
Black Gloss



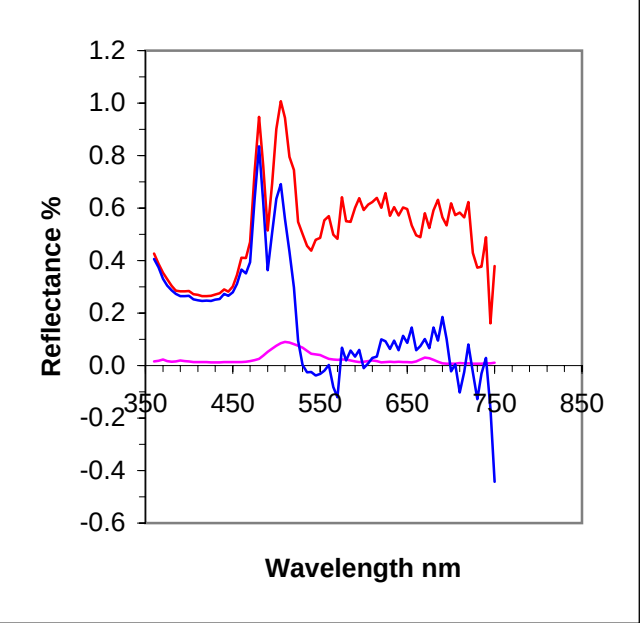
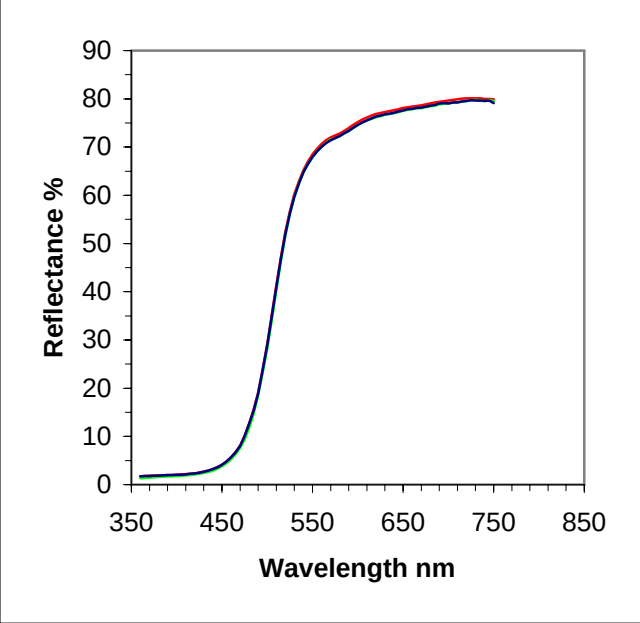
Red
Gloss



Cyan
Gloss



**Blue
Gloss**



**Yellow
Gloss**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 10 mm (Medium)

Geometry: SPEX

Tiles: Gloss

NPL Master Tiles: Colours Set ½

White WT53

Black BT03

Grey GT51

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0127	R%	+	0.0873
450 nm	Uncert =	0.0084	R%	+	0.0551
500 nm	Uncert =	0.0112	R%	+	0.0543
550 nm	Uncert =	0.0096	R%	+	0.0637
600 nm	Uncert =	0.0100	R%	+	0.0710
650 nm	Uncert =	0.0100	R%	+	0.0914
700 nm	Uncert =	0.0120	R%	+	0.0553

<= 460 nm Uncert = **0.013** R% + **0.090** (k = 2)

>= 465 nm Uncert = **0.011** R% + **0.090** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	0.39	0.89
a*	0.07	1.05
b*	0.06	0.80

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0060	R%	+	0.0600
450 nm	Uncert =	0.0059	R%	+	0.0569
500 nm	Uncert =	0.0060	R%	+	0.0585
550 nm	Uncert =	0.0059	R%	+	0.0682
600 nm	Uncert =	0.0060	R%	+	0.0678
650 nm	Uncert =	0.0059	R%	+	0.0766
700 nm	Uncert =	0.0060	R%	+	0.0695

<= 460 nm Uncert = **0.0054** R% + **0.220** (k = 2)

>= 460 nm Uncert = **0.0054** R% + **0.220** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	0.38	2.02
a*	0.10	2.79
b*	0.09	2.32

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.06	0.75	0.35	0.35	0.14	0.21	0.19	0.49	0.80	0.30	0.31	0.28	0.10	0.10	0.61
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	0.0010	0.0035	0.0007	0.0004	0.0004	0.0003	0.0004	0.0039	0.0071	< 0.0001
y	0.0002	0.0002	0.0002	0.0002	0.0003	< 0.0001	0.0001	0.0005	0.0004	0.0007	0.0008	0.0002	0.0070	0.0013	0.0002
L*	0.45	0.42	0.36	0.36	0.43	0.36	0.38	0.39	0.42	0.36	0.36	0.36	0.89	0.86	0.40
a*	0.04	0.03	0.02	0.02	0.02	0.09	0.19	0.14	0.16	0.13	0.13	0.07	1.05	0.01	0.03
b*	0.07	0.06	0.05	0.04	0.04	0.07	0.76	0.19	0.06	0.03	0.04	0.10	0.80	0.02	0.06

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

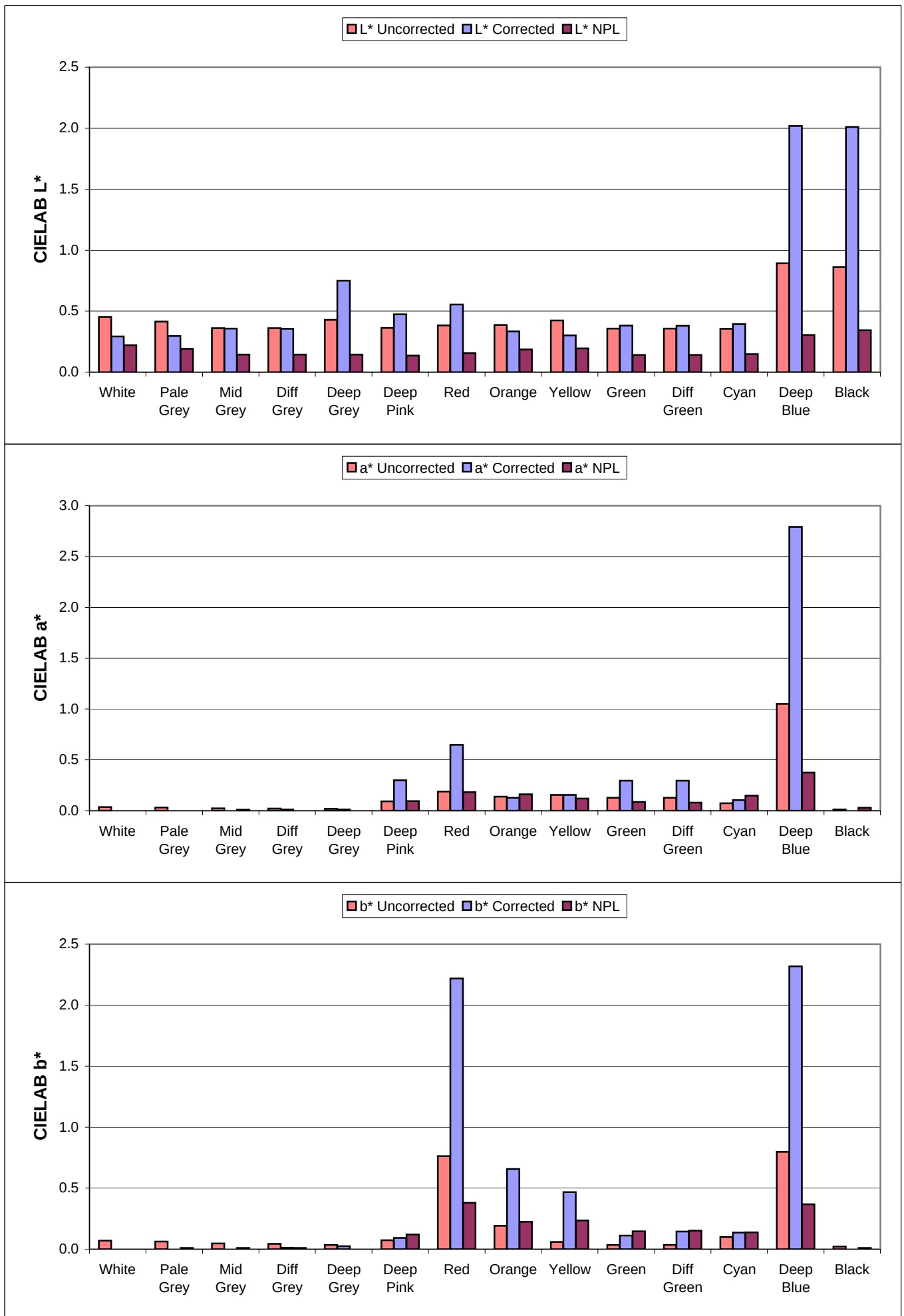
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.68	0.54	0.34	0.35	0.24	0.28	0.27	0.42	0.57	0.32	0.32	0.31	0.23	0.22	0.47
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	0.0020	0.0086	0.0017	0.0008	0.0007	0.0006	0.0011	0.0100	0.0263	< 0.0001
y	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	0.0004	0.0001	0.0007	0.0009	0.0014	0.0016	0.0009	0.0184	0.0058	< 0.0001
L*	0.29	0.30	0.36	0.36	0.75	0.47	0.55	0.34	0.30	0.38	0.38	0.39	2.02	2.01	0.30
a*	< 0.01	< 0.01	< 0.01	0.01	0.01	0.30	0.65	0.13	0.16	0.30	0.29	0.10	2.79	< 0.01	< 0.01
b*	< 0.01	< 0.01	< 0.01	0.01	0.02	0.09	2.22	0.66	0.47	0.11	0.15	0.14	2.32	< 0.01	< 0.01

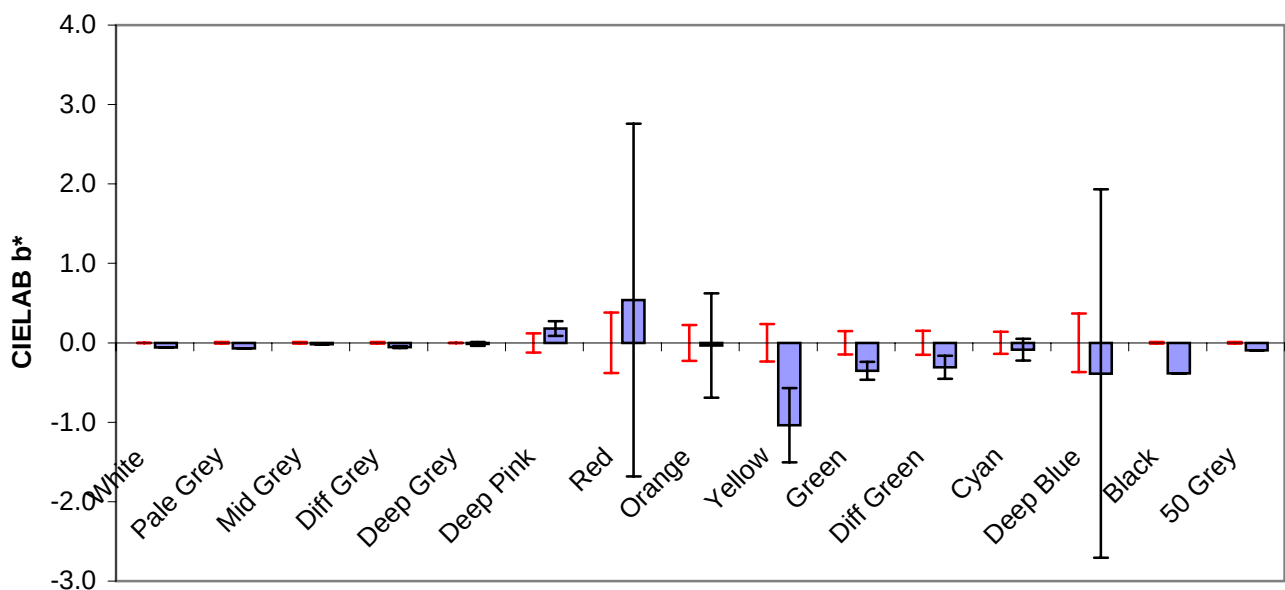
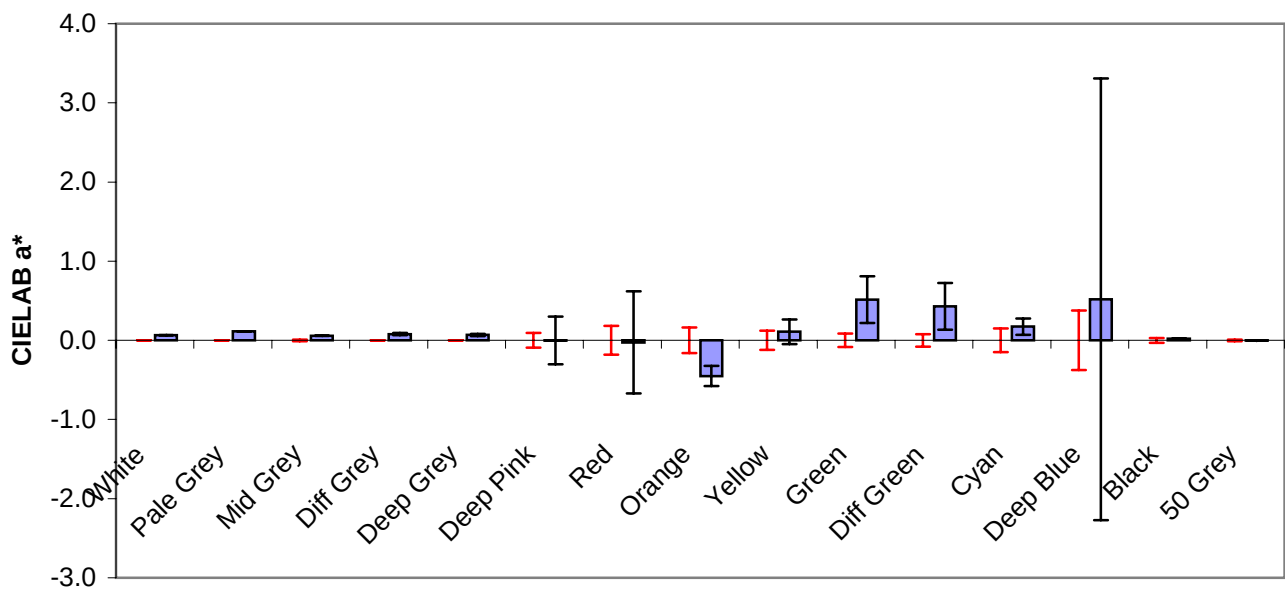
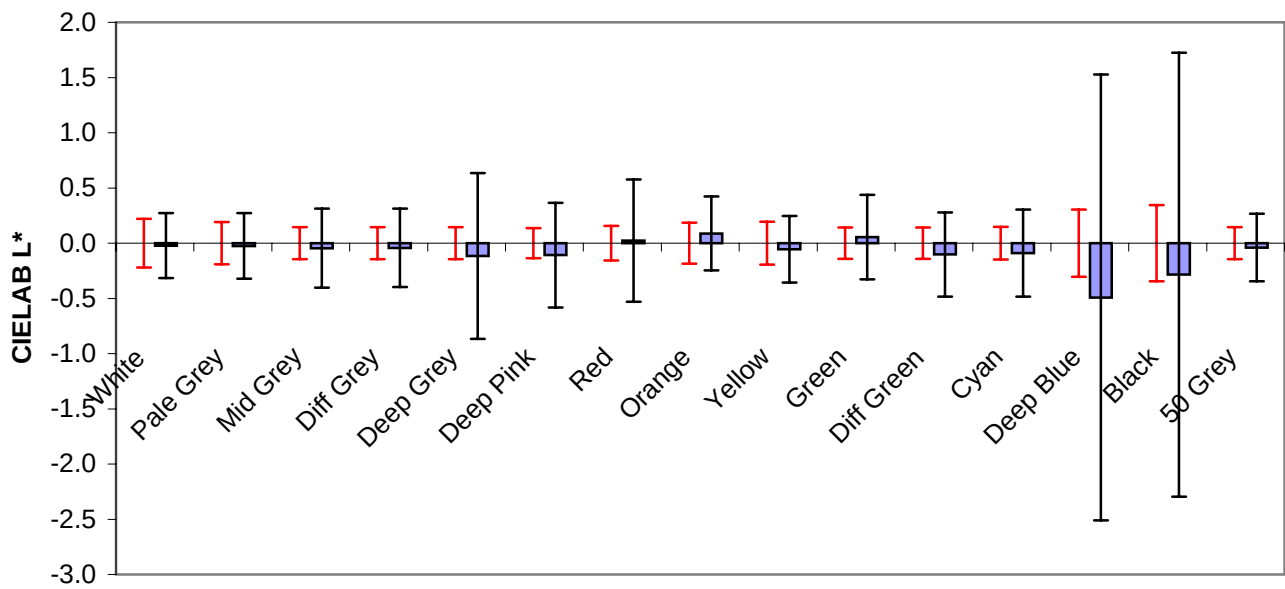
NPL Lambda Uncertainty

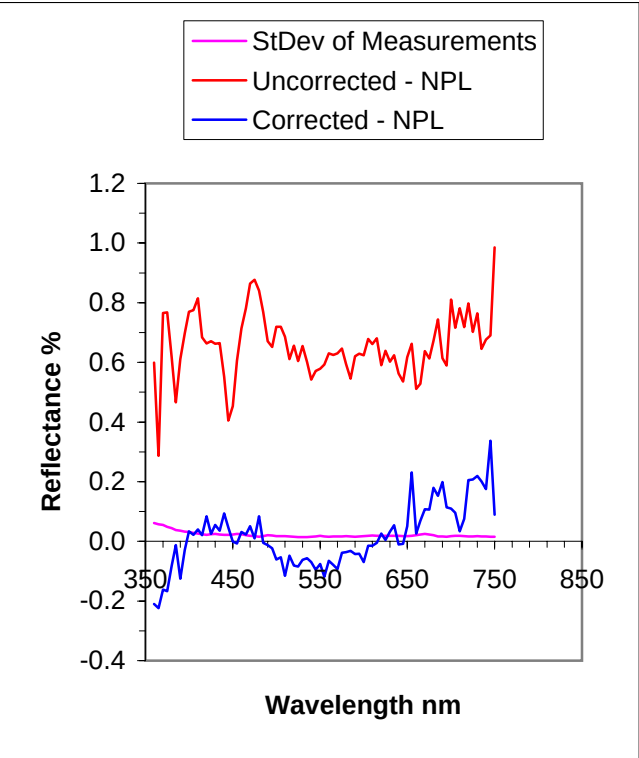
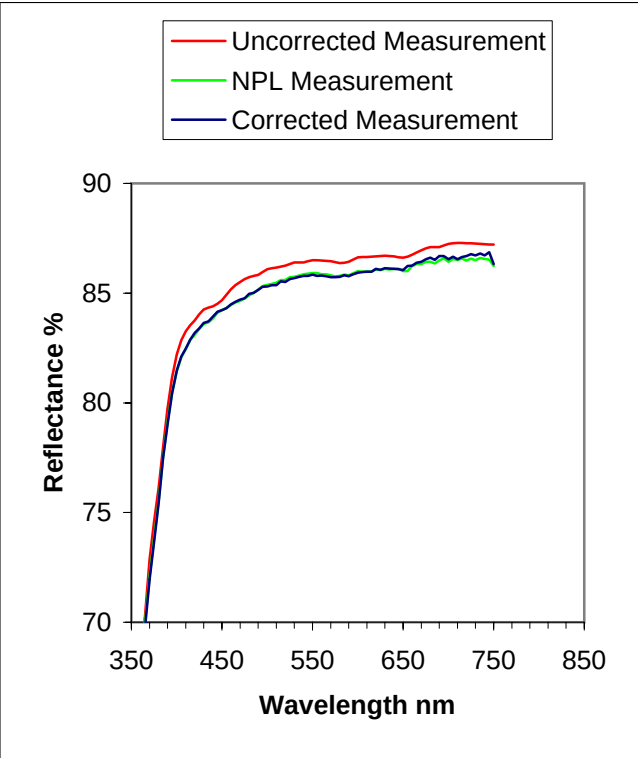
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.51	0.35	0.15	0.15	0.05	0.08	0.08	0.22	0.36	0.12	0.12	0.12	0.04	0.04	0.15
x	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0006	0.0015	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	< 0.0001
y	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0001	0.0004	0.0001	0.0006	0.0006	0.0005	0.0027	0.0000	< 0.0001
L*	0.22	0.19	0.15	0.15	0.14	0.14	0.16	0.19	0.20	0.14	0.14	0.15	0.30	0.34	0.15
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.09	0.18	0.16	0.12	0.08	0.08	0.15	0.38	0.03	0.01
b*	< 0.01	0.01	0.01	0.01	< 0.01	0.12	0.38	0.23	0.24	0.15	0.15	0.14	0.37	0.01	0.01

Colorimetry

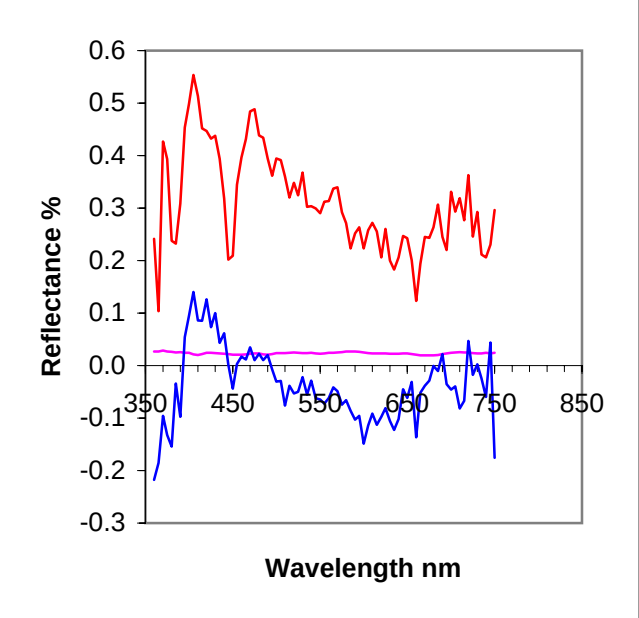
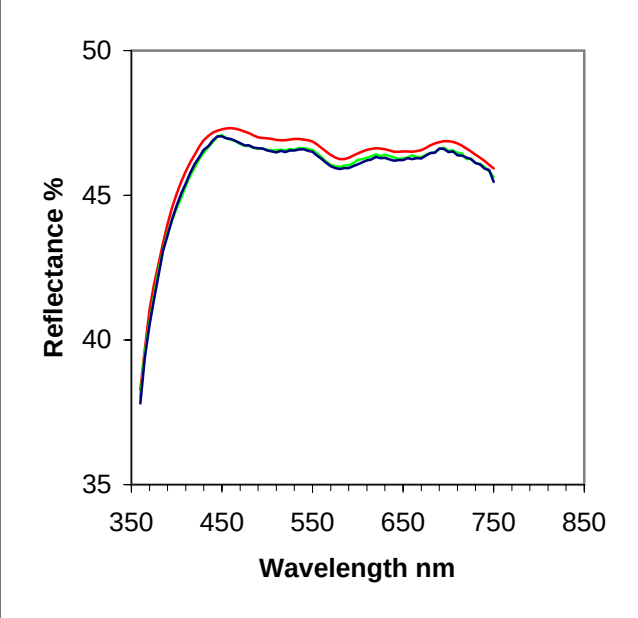
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	94.48	81.40	55.14	55.43	25.70	39.74	34.56	65.06	83.27	50.65	50.86	48.68	8.63	4.41	73.97
		a*	-0.32	-0.42	-0.46	-2.77	-0.42	29.89	55.08	39.80	-4.99	-34.27	-34.63	-12.23	24.26	-1.49	-0.17
		b*	1.06	0.35	0.21	2.36	0.77	5.93	41.40	64.38	85.92	14.14	17.51	-33.05	-34.02	-0.95	-0.47
Average Measurement (Uncorrected)	B	L*	94.48	81.38	55.13	55.43	25.69	39.74	34.46	65.04	83.23	50.58	50.81	48.63	8.66	4.32	73.99
		a*	-0.33	-0.43	-0.48	-2.76	-0.42	29.87	55.12	39.85	-4.89	-34.25	-34.53	-12.16	24.15	-1.51	-0.18
		b*	1.09	0.33	0.20	2.36	0.76	5.91	41.61	64.30	85.97	14.14	17.53	-33.09	-33.95	-0.96	-0.45
Average Measurement (Corrected)	C	L*	94.19	81.12	54.95	55.24	25.58	39.60	34.33	64.84	82.97	50.41	50.63	48.46	8.60	4.28	73.76
		a*	-0.26	-0.37	-0.43	-2.71	-0.39	29.83	55.01	39.78	-4.83	-34.12	-34.41	-12.07	24.12	-1.49	-0.13
		b*	1.06	0.31	0.18	2.34	0.75	5.88	41.51	64.13	85.76	14.10	17.48	-33.03	-33.88	-0.96	-0.47
NPL Values	D	L*	94.21	81.15	54.99	55.29	25.69	39.71	34.31	64.75	83.03	50.35	50.73	48.55	9.09	4.57	73.80
		a*	-0.32	-0.48	-0.49	-2.79	-0.46	29.84	55.04	40.23	-4.94	-34.63	-34.84	-12.25	23.61	-1.51	-0.12
		b*	1.12	0.38	0.20	2.39	0.76	5.70	40.98	64.17	86.80	14.45	17.79	-32.95	-33.50	-0.58	-0.37
A to B		dE*	0.025	0.034	0.020	0.016	0.015	0.030	0.237	0.097	0.119	0.068	0.109	0.090	0.133	0.094	0.034
B to C		dE*	0.299	0.263	0.192	0.195	0.113	0.149	0.192	0.275	0.338	0.221	0.223	0.205	0.097	0.040	0.243
B to D		dE*	0.269	0.239	0.142	0.151	0.042	0.211	0.657	0.498	0.852	0.548	0.405	0.188	0.829	0.462	0.218
C to D		dE*	0.090	0.135	0.076	0.105	0.136	0.211	0.539	0.460	1.045	0.625	0.538	0.213	0.812	0.479	0.101
Corrected + Uncertainty	E	L*	94.48	81.42	55.30	55.60	26.33	40.08	34.89	65.17	83.27	50.79	51.01	48.85	10.61	6.29	74.06
		a*	-0.26	-0.37	-0.43	-2.69	-0.38	30.13	55.66	39.90	-4.68	-33.82	-34.11	-11.97	26.91	-1.48	-0.12
		b*	1.06	0.31	0.19	2.35	0.77	5.98	43.73	64.79	86.23	14.21	17.62	-32.90	-31.57	-0.96	-0.46
Corrected - Uncertainty	F	L*	93.89	80.82	54.59	54.89	24.83	39.13	33.78	64.50	82.67	50.02	50.25	48.06	6.58	2.27	73.45
		a*	-0.26	-0.37	-0.44	-2.72	-0.40	29.53	54.36	39.65	-4.99	-34.41	-34.70	-12.18	21.33	-1.50	-0.13
		b*	1.06	0.31	0.18	2.33	0.72	5.79	39.29	63.47	85.29	13.99	17.33	-33.17	-36.20	-0.97	-0.47



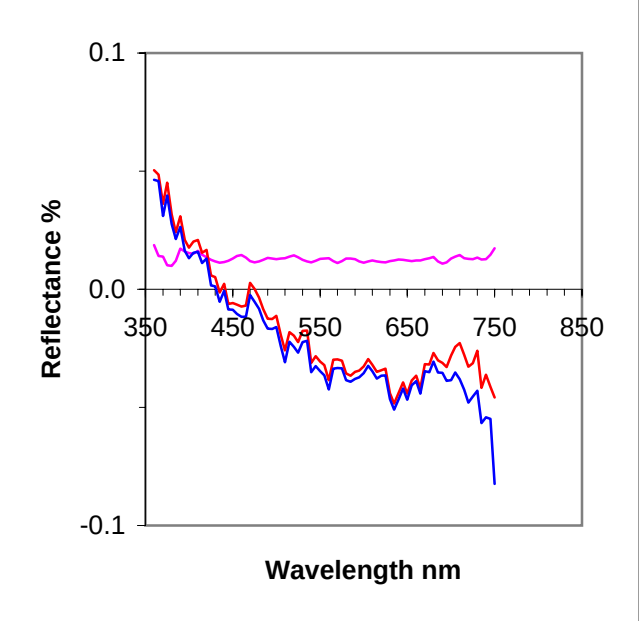
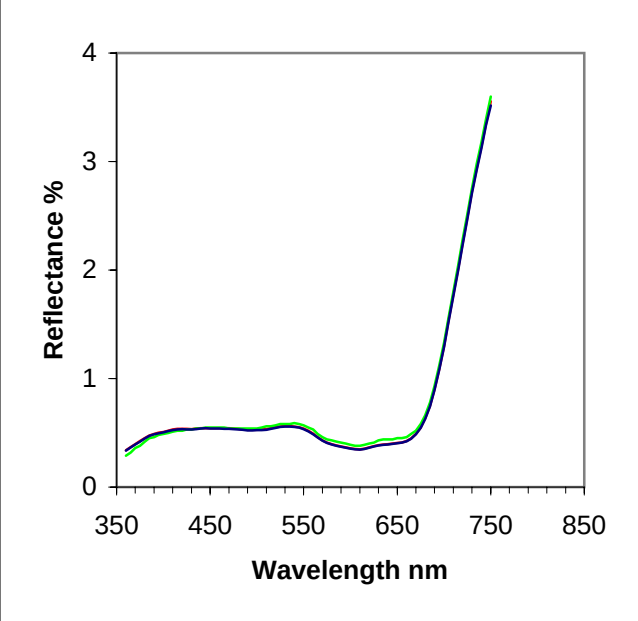




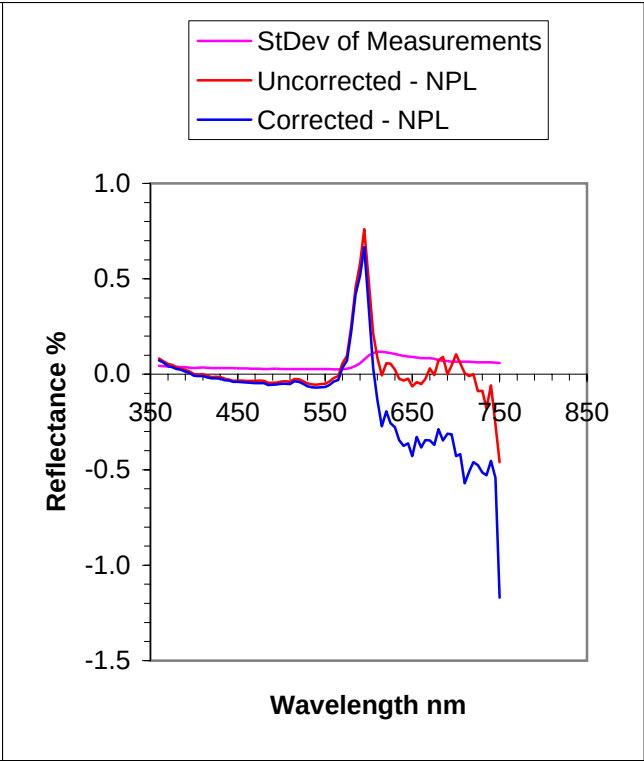
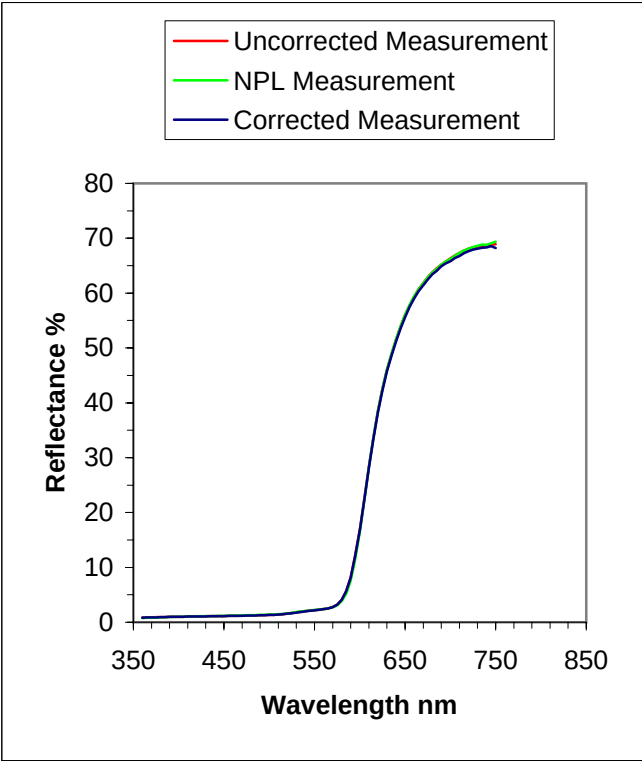
**White
Gloss**



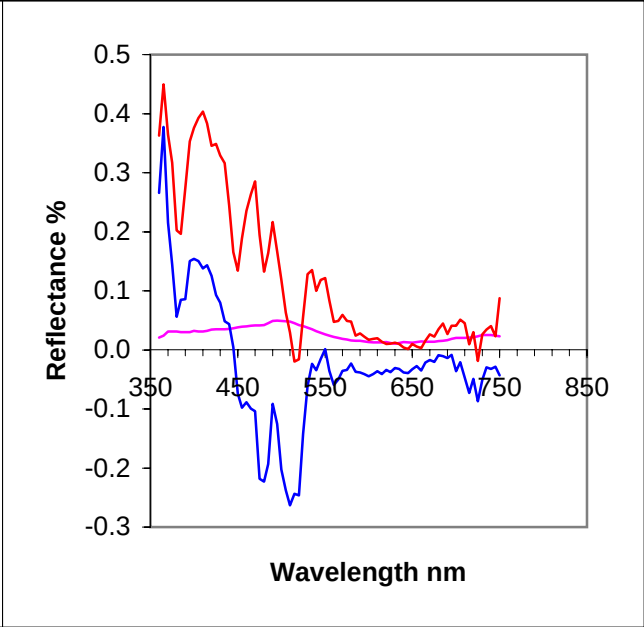
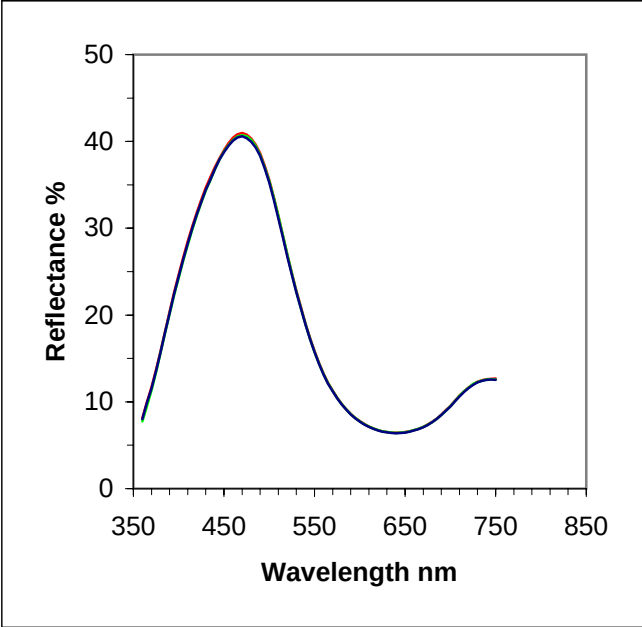
**50 Grey
Gloss**



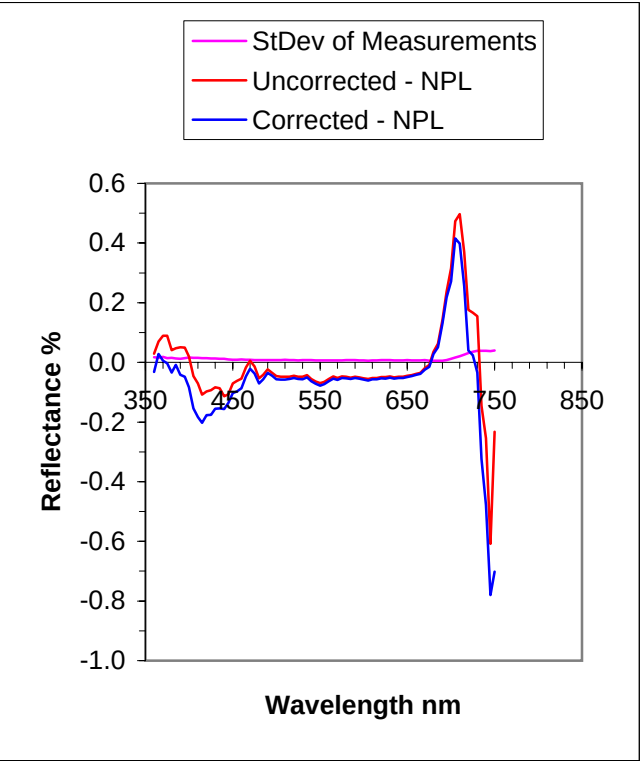
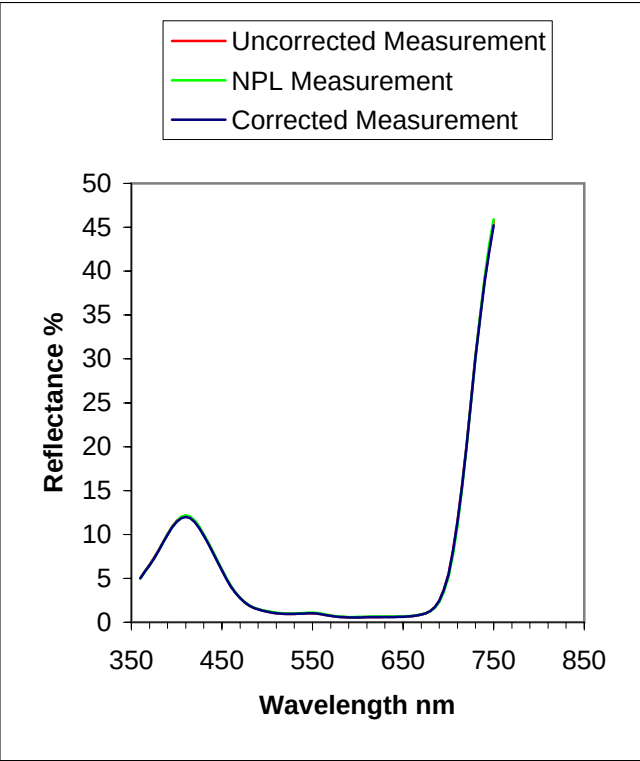
**Black
Gloss**



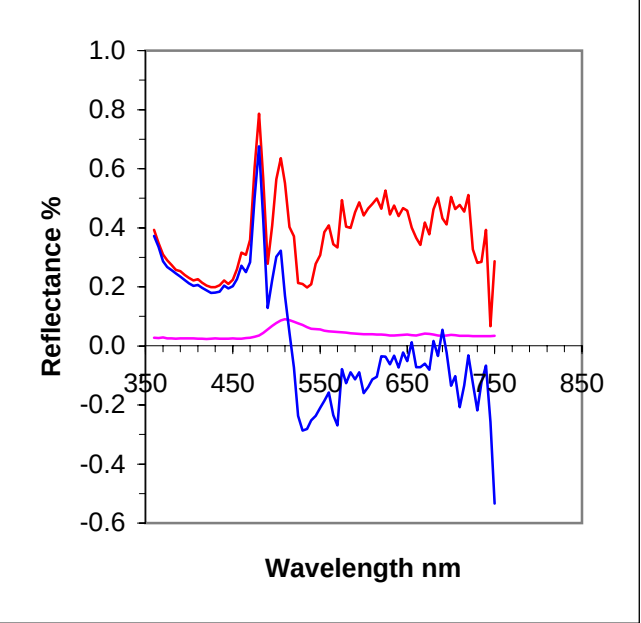
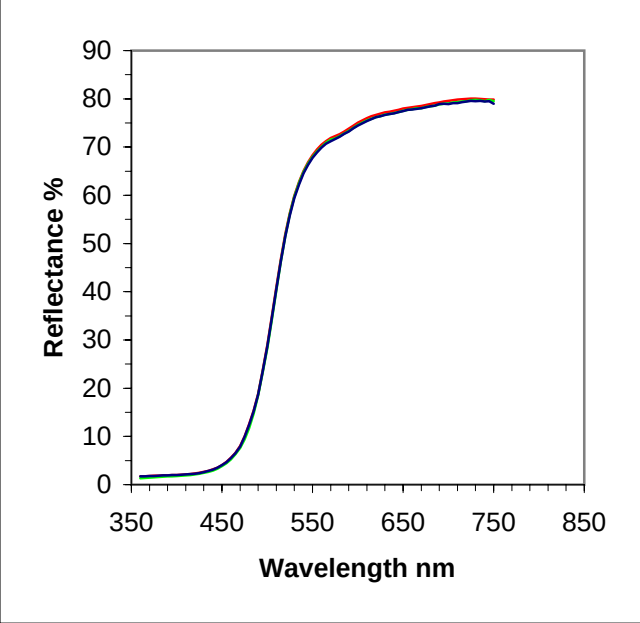
**Red
Gloss**



**Cyan
Gloss**



Blue
Gloss



Yellow
Gloss

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 3 mm (Small)

Geometry: SPEX

Tiles: Gloss

NPL Master Tiles: Colours Set ½

White WT53

Black BT03

Grey GT51

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0811	R%	+	0.6839
450 nm	Uncert =	0.0764	R%	+	0.6127
500 nm	Uncert =	0.0779	R%	+	0.6241
550 nm	Uncert =	0.0750	R%	+	0.6605
600 nm	Uncert =	0.0760	R%	+	0.7648
650 nm	Uncert =	0.0763	R%	+	0.7826
700 nm	Uncert =	0.0787	R%	+	0.6580

<= 460 nm Uncert = **0.080** R% + **0.700** (k = 2)

>= 465 nm Uncert = **0.080** R% + **0.800** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	3.04	7.76
a*	0.20	8.13
b*	0.12	7.71

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0701	R%	+	0.6777
450 nm	Uncert =	0.0698	R%	+	0.6094
500 nm	Uncert =	0.0668	R%	+	0.6184
550 nm	Uncert =	0.0658	R%	+	0.6554
600 nm	Uncert =	0.0662	R%	+	0.7586
650 nm	Uncert =	0.0683	R%	+	0.7775
700 nm	Uncert =	0.0688	R%	+	0.6530

<= 460 nm Uncert = **0.07** R% + **0.800** (k = 2)

>= 460 nm Uncert = **0.07** R% + **0.800** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	2.75	7.67
a*	0.17	7.83
b*	0.17	7.98

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	8.10	5.85	2.77	2.80	1.20	1.75	1.48	3.56	5.86	2.41	2.42	2.26	0.90	0.85	4.78
x	< 0.0001	< 0.0001	0.0002	0.0002	0.0008	0.0067	0.0326	0.0063	0.0026	0.0025	0.0022	0.0041	0.0408	0.1152	0.0001
y	< 0.0001	0.0001	0.0004	< 0.0001	0.0015	0.0023	0.0010	0.0019	0.0029	0.0043	0.0051	0.0035	0.0747	0.0570	0.0002
L*	3.43	3.17	2.83	2.84	3.71	2.95	3.15	2.90	3.17	2.83	2.83	2.83	7.76	7.66	3.04
a*	0.03	0.04	0.06	0.07	0.15	0.53	1.38	0.51	0.20	0.22	0.22	0.05	8.13	0.64	0.04
b*	0.07	0.07	0.12	0.13	0.30	0.09	6.83	0.80	0.48	0.10	0.07	0.10	7.71	0.92	0.06

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

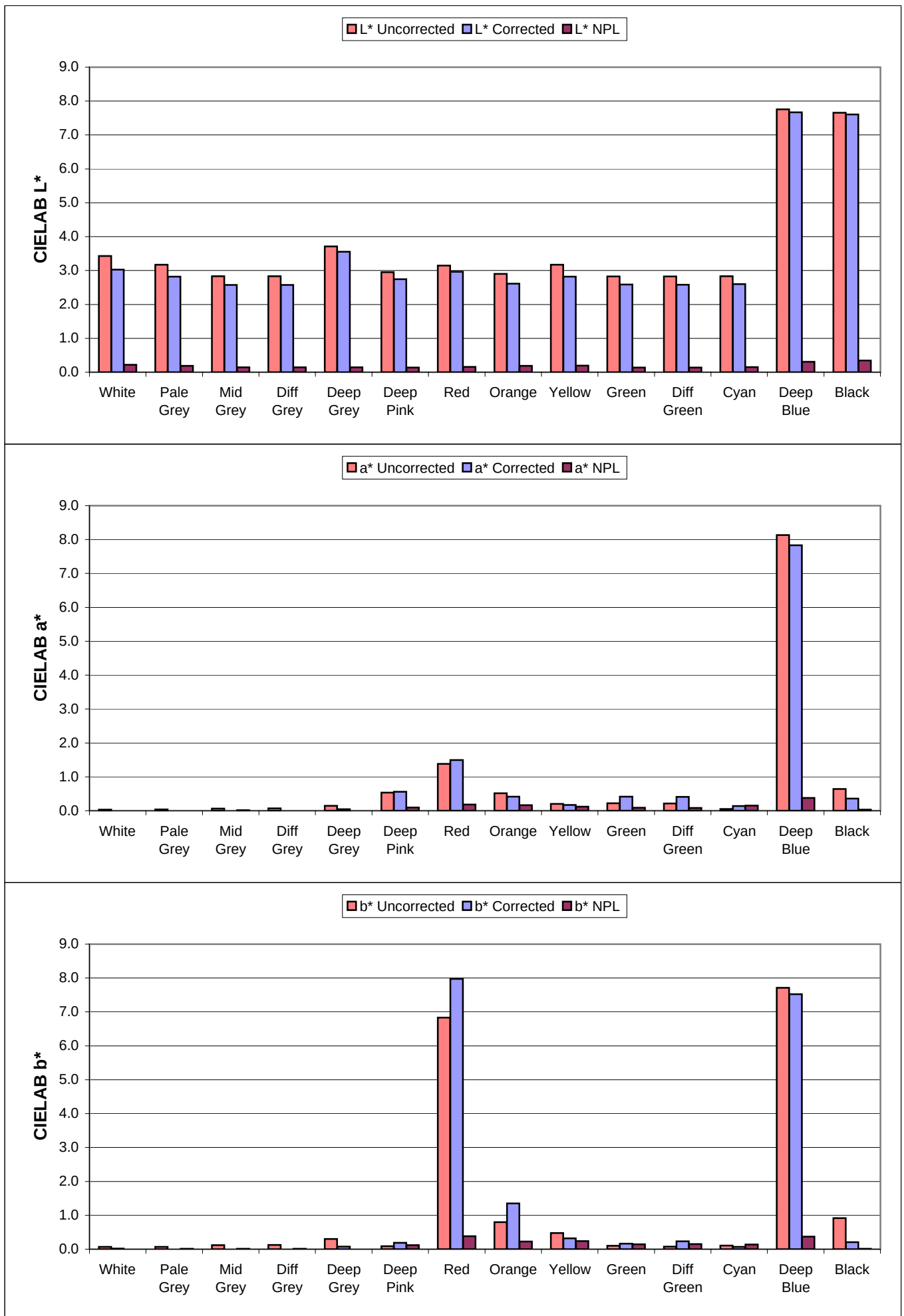
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	7.14	5.19	2.51	2.54	1.15	1.62	1.39	3.20	5.19	2.19	2.21	2.07	0.89	0.84	4.26
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004	0.0074	0.0344	0.0067	0.0028	0.0023	0.0019	0.0041	0.0406	0.0863	< 0.0001
y	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0008	0.0016	0.0003	0.0023	0.0033	0.0051	0.0060	0.0032	0.0739	0.0131	< 0.0001
L*	3.03	2.82	2.57	2.57	3.55	2.75	2.97	2.61	2.82	2.59	2.58	2.60	7.67	7.61	2.71
a*	< 0.01	< 0.01	< 0.01	< 0.01	0.04	0.56	1.49	0.42	0.17	0.41	0.41	0.14	7.83	0.36	< 0.01
b*	0.02	< 0.01	< 0.01	< 0.01	0.07	0.19	7.98	1.35	0.32	0.17	0.23	0.07	7.53	0.21	< 0.01

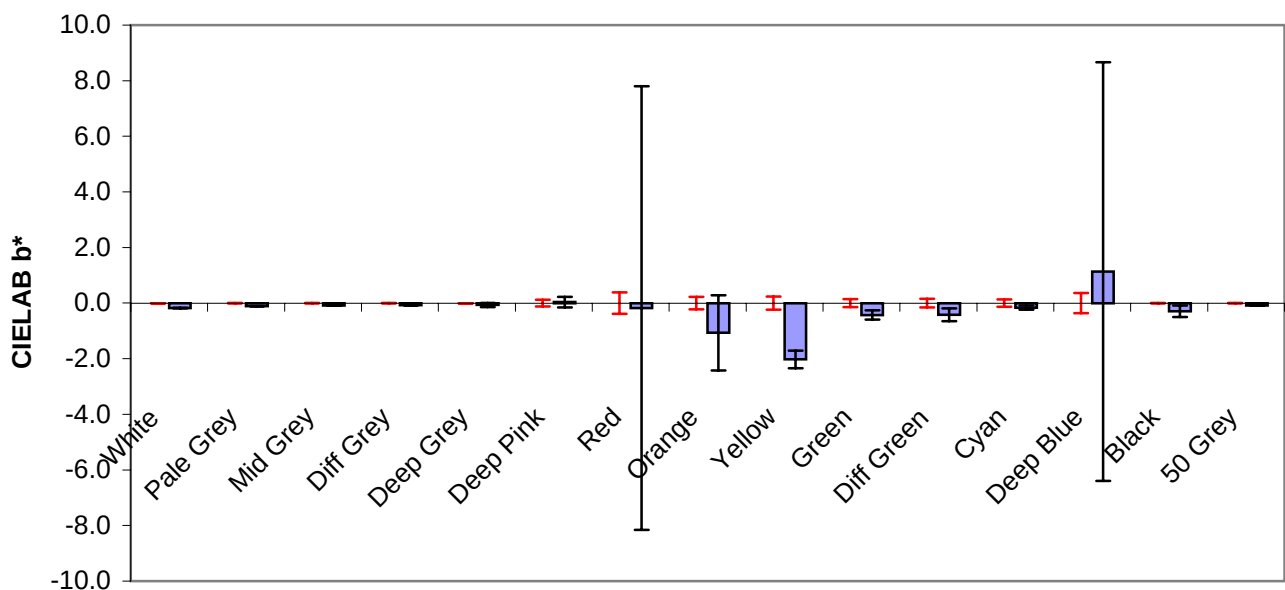
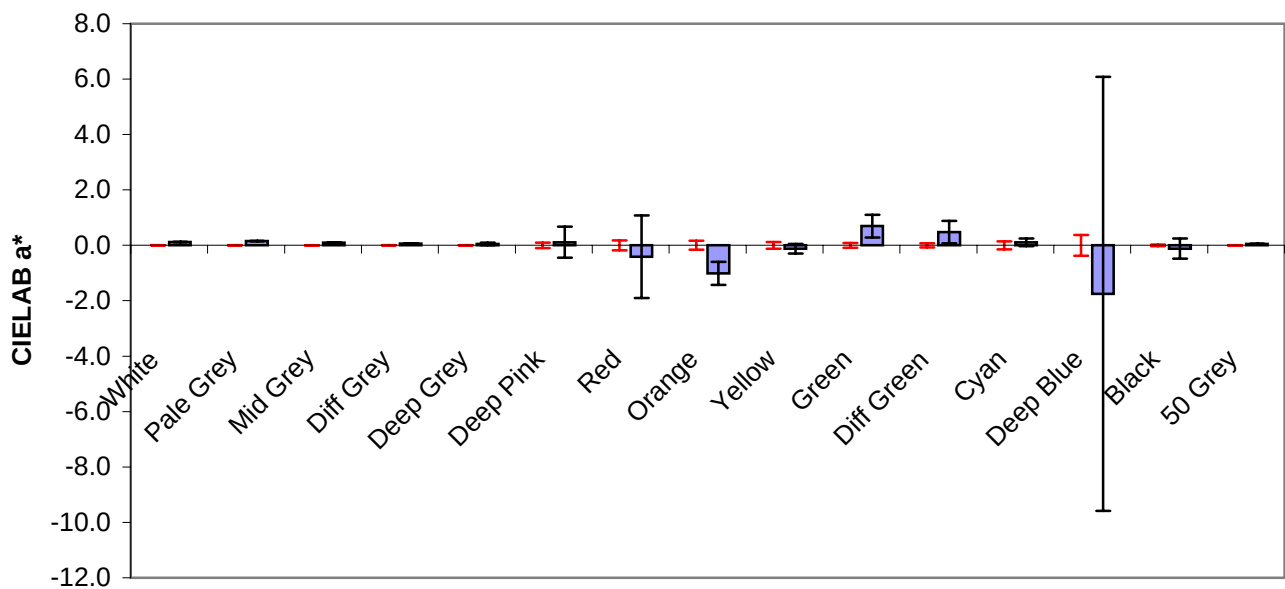
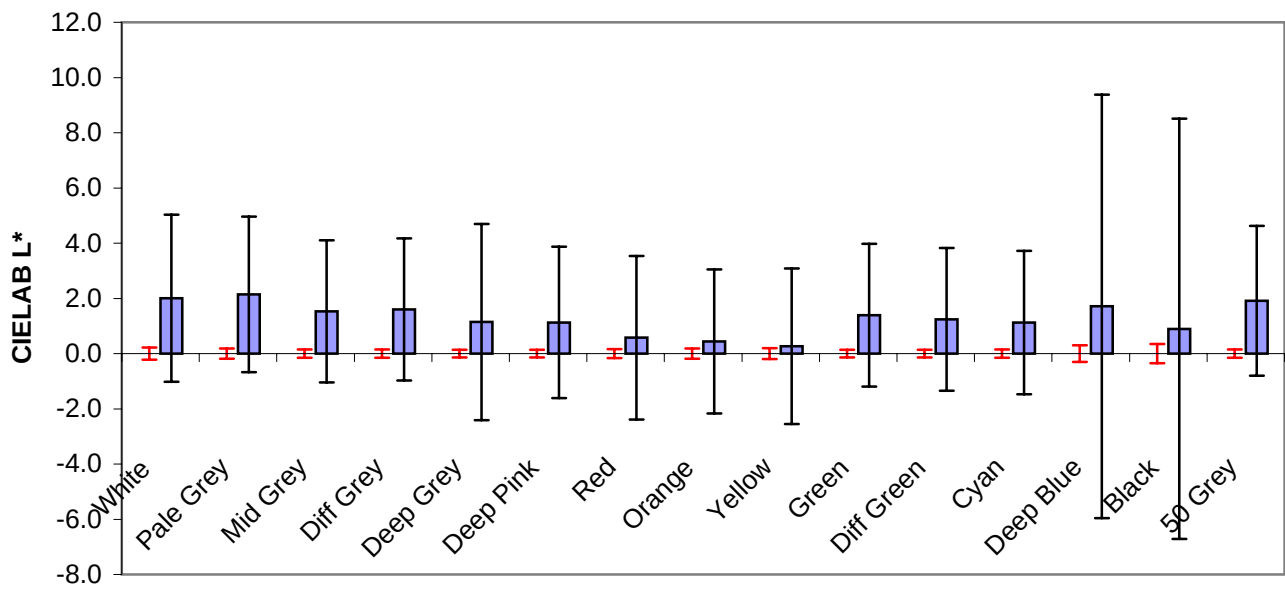
NPL Lambda Uncertainty

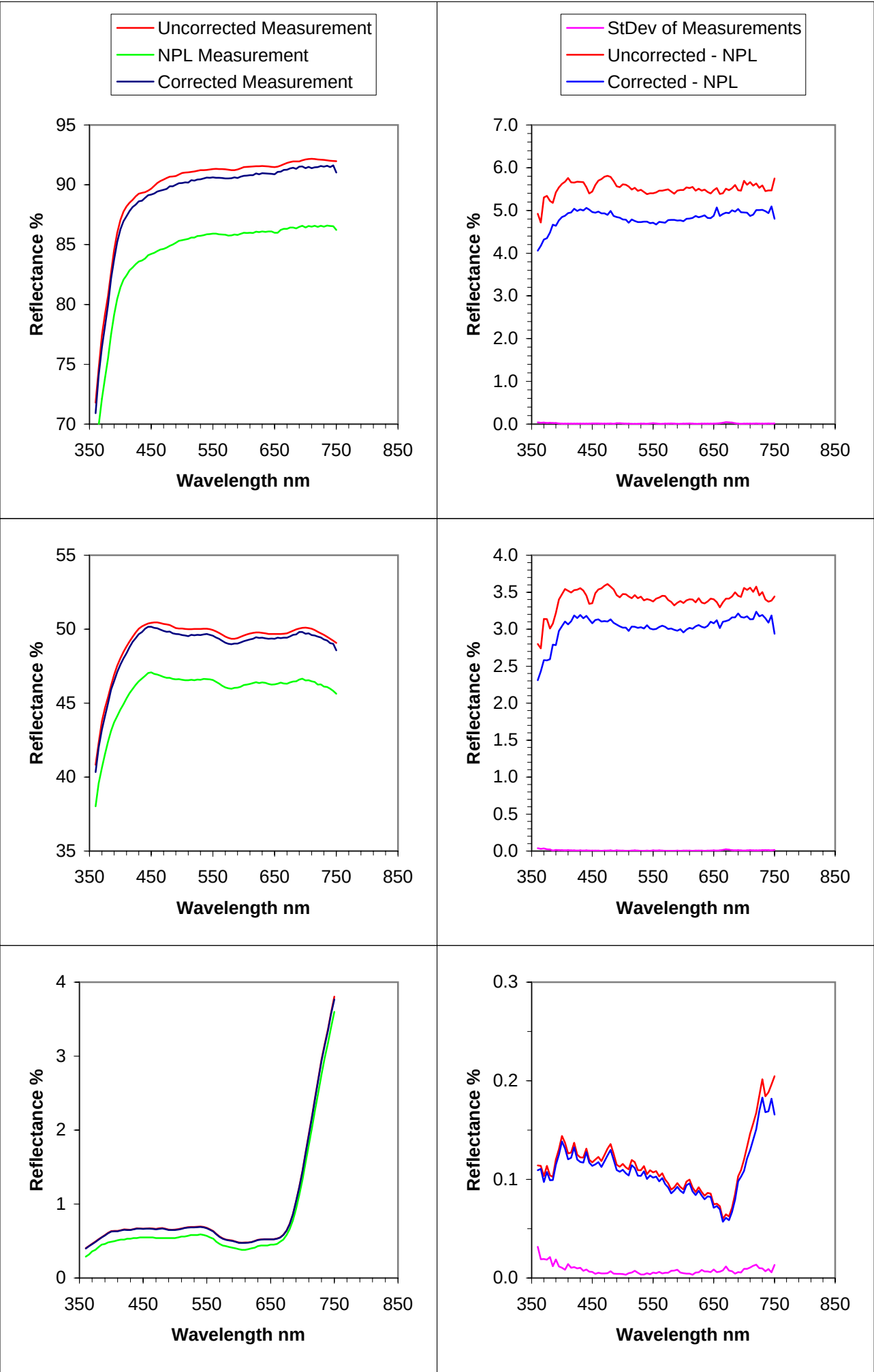
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.51	0.35	0.15	0.15	0.05	0.08	0.08	0.22	0.36	0.12	0.12	0.12	0.04	0.04	0.15
x	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0006	0.0015	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	< 0.0001
y	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0001	0.0004	0.0001	0.0006	0.0006	0.0005	0.0027	0.0000	< 0.0001
L*	0.22	0.19	0.15	0.15	0.14	0.14	0.16	0.19	0.20	0.14	0.14	0.15	0.30	0.34	0.15
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.09	0.18	0.16	0.12	0.08	0.08	0.15	0.38	0.03	0.01
b*	< 0.01	0.01	0.01	0.01	< 0.01	0.12	0.38	0.23	0.24	0.15	0.15	0.14	0.37	0.01	0.01

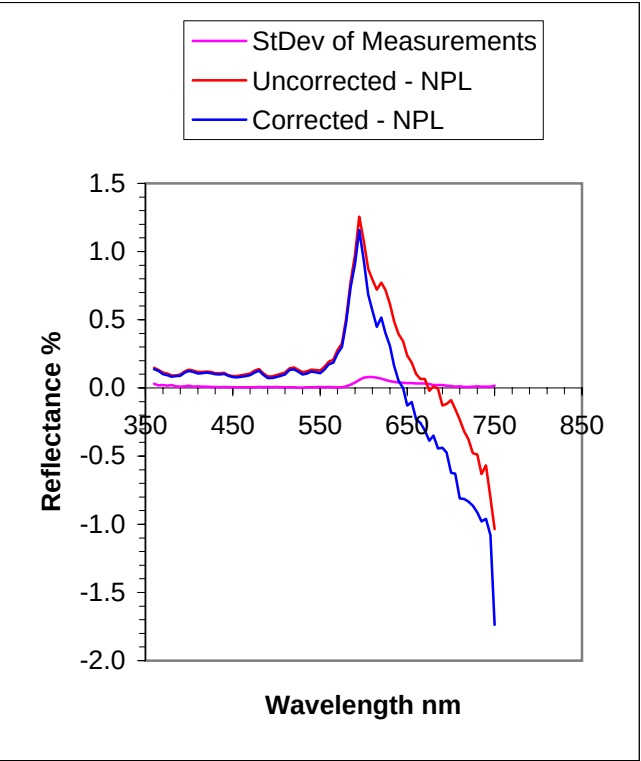
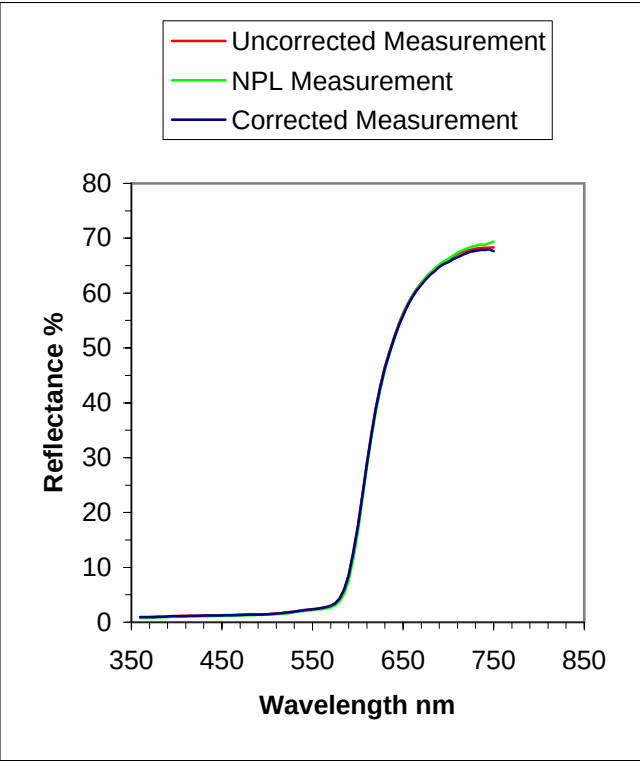
Colorimetry

			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	96.51	83.55	56.71	57.07	26.94	40.99	35.06	65.44	83.59	51.93	52.17	49.85	10.84	5.48	75.95
		a*	-0.27	-0.38	-0.42	-2.78	-0.42	30.05	54.80	39.23	-5.18	-34.12	-34.56	-12.26	21.93	-1.59	-0.13
		b*	0.97	0.29	0.12	2.33	0.70	5.78	41.02	63.34	85.01	14.06	17.41	-33.17	-32.45	-0.89	-0.44
Average Measurement (Uncorrected)	B	L*	96.51	83.55	56.71	57.08	26.95	40.98	35.01	65.39	83.55	51.92	52.16	49.85	10.87	5.51	75.95
		a*	-0.28	-0.38	-0.43	-2.78	-0.44	29.99	54.74	39.28	-5.12	-34.07	-34.49	-12.23	21.88	-1.65	-0.13
		b*	0.97	0.30	0.13	2.34	0.71	5.77	40.89	63.26	84.98	14.06	17.41	-33.17	-32.42	-0.87	-0.44
Average Measurement (Corrected)	C	L*	96.21	83.29	56.52	56.88	26.84	40.84	34.89	65.19	83.29	51.74	51.98	49.67	10.80	5.46	75.71
		a*	-0.21	-0.32	-0.39	-2.73	-0.41	29.95	54.62	39.22	-5.07	-33.94	-34.36	-12.14	21.85	-1.63	-0.07
		b*	0.94	0.27	0.11	2.32	0.69	5.74	40.80	63.10	84.77	14.02	17.36	-33.11	-32.36	-0.87	-0.46
NPL Values	D	L*	94.21	81.15	54.99	55.29	25.69	39.71	34.31	64.75	83.03	50.35	50.73	48.55	9.09	4.57	73.80
		a*	-0.32	-0.48	-0.49	-2.79	-0.46	29.84	55.04	40.23	-4.94	-34.63	-34.84	-12.25	23.61	-1.51	-0.12
		b*	1.12	0.38	0.20	2.39	0.76	5.70	40.98	64.17	86.80	14.45	17.79	-32.95	-33.50	-0.58	-0.37
A to B		dE*	0.008	0.010	0.018	0.010	0.024	0.060	0.149	0.110	0.074	0.056	0.072	0.030	0.069	0.072	0.003
B to C		dE*	0.304	0.269	0.197	0.199	0.116	0.152	0.192	0.274	0.337	0.224	0.226	0.208	0.097	0.049	0.248
B to D		dE*	2.304	2.406	1.722	1.790	1.260	1.285	0.764	1.457	1.896	1.715	1.512	1.318	2.704	0.995	2.151
C to D		dE*	2.016	2.150	1.535	1.601	1.149	1.136	0.729	1.536	2.045	1.612	1.396	1.139	2.699	0.951	1.912
Corrected + Uncertainty	E	L*	99.24	86.11	59.09	59.46	30.39	43.58	37.85	67.80	86.11	54.33	54.56	52.27	18.47	13.07	78.42
		a*	-0.21	-0.32	-0.39	-2.72	-0.37	30.51	56.12	39.63	-4.89	-33.53	-33.95	-12.00	29.69	-1.27	-0.07
		b*	0.96	0.28	0.12	2.33	0.77	5.93	48.77	64.44	85.09	14.19	17.60	-33.04	-24.83	-0.66	-0.45
Corrected - Uncertainty	F	L*	93.18	80.47	53.95	54.31	23.29	38.09	31.92	62.58	80.47	49.16	49.39	47.07	3.13	-2.15	72.99
		a*	-0.21	-0.33	-0.39	-2.73	-0.45	29.39	53.13	38.80	-5.24	-34.35	-34.77	-12.27	14.02	-1.99	-0.07
		b*	0.92	0.27	0.11	2.31	0.62	5.55	32.82	61.75	84.45	13.85	17.13	-33.18	-39.89	-1.08	-0.47

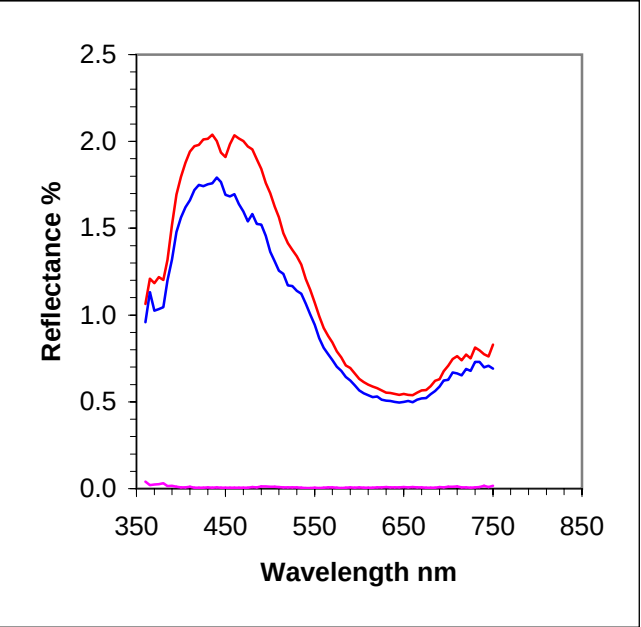
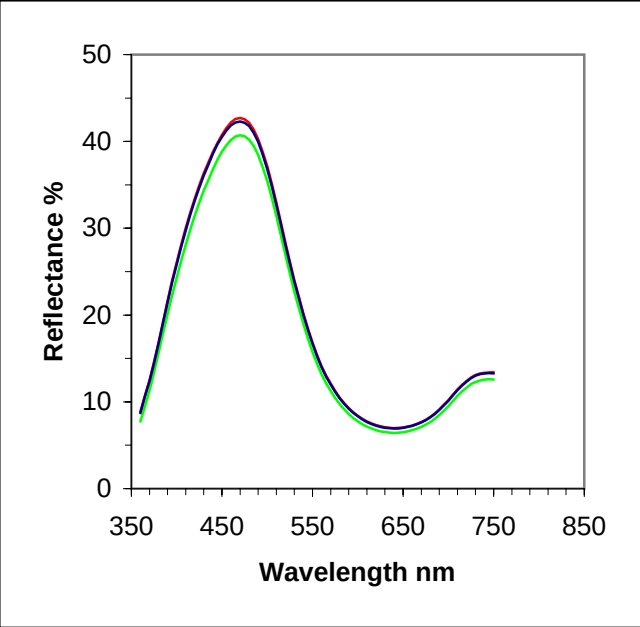




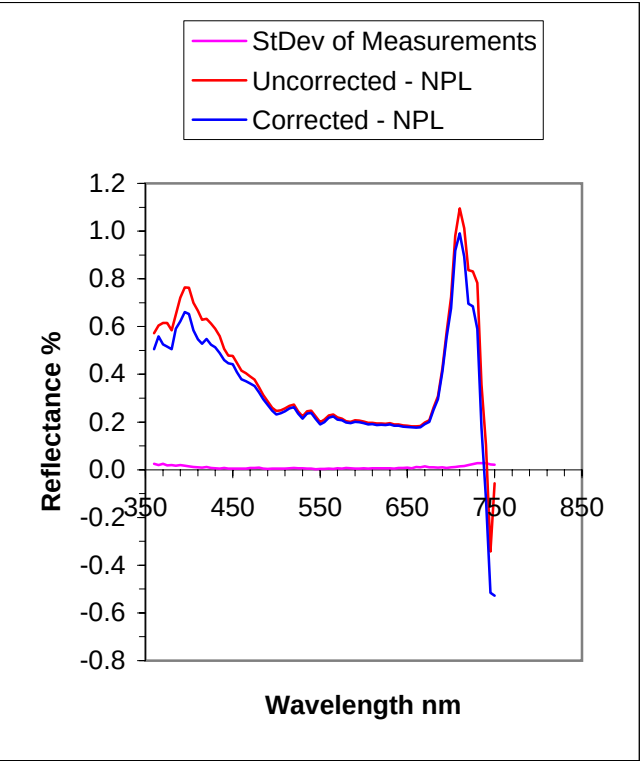
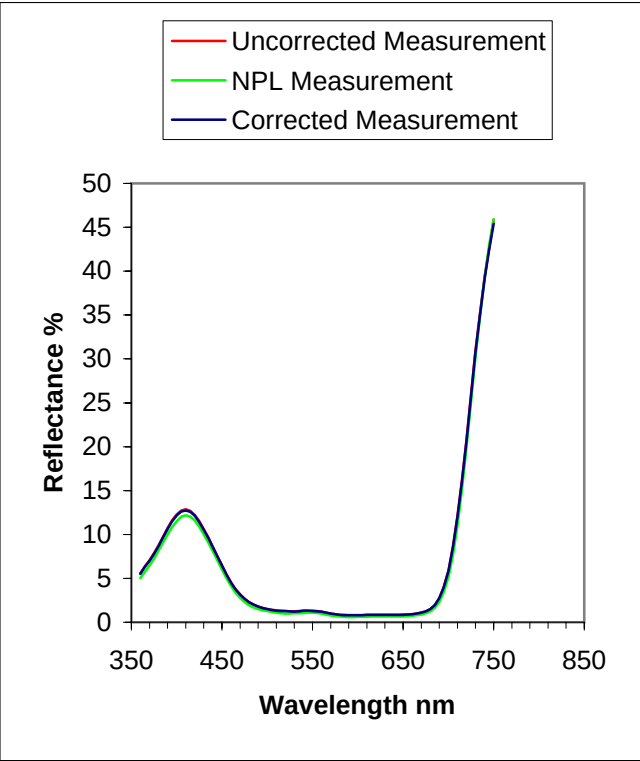




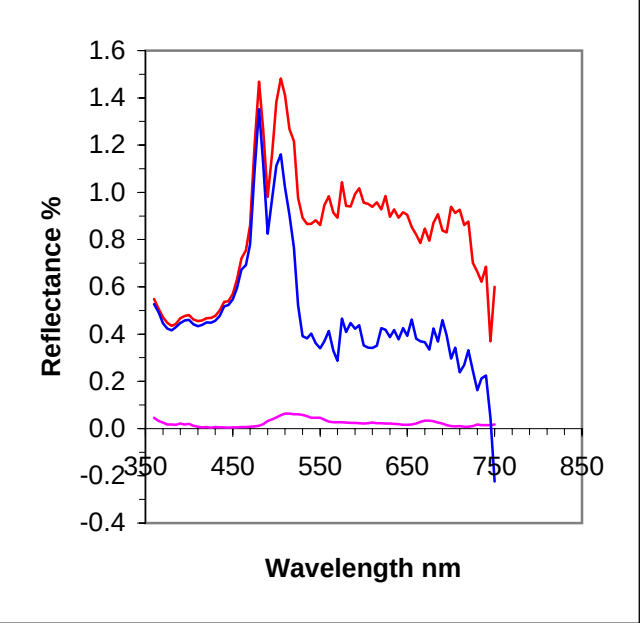
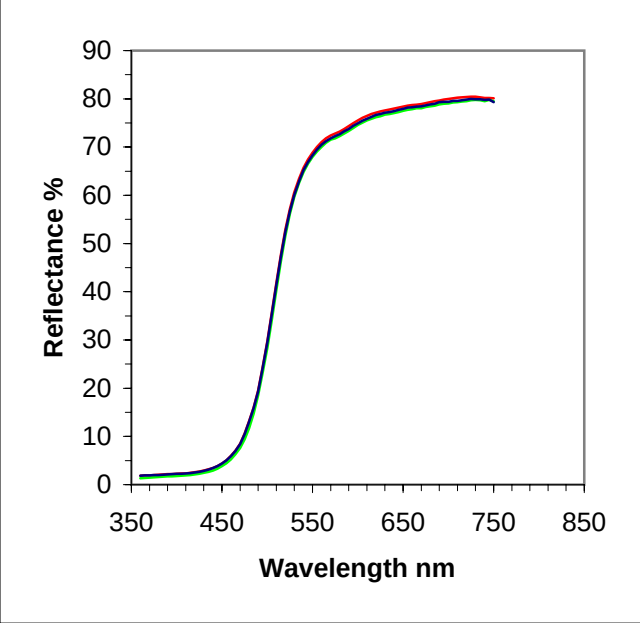
**Red
Gloss**



**Cyan
Gloss**



**Blue
Gloss**



**Yellow
Gloss**

INSTRUMENT CHARACTERISATION

23-Sep-05

Instrument: Instrument 1

NPL Master Tiles: Colours CCM6

Aperture: 25 mm (Large)

White WT45

Geometry: SPIN

Black BT10

Tiles: Matt

Grey GT41

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0121	R%	+	0.0840
450 nm	Uncert =	0.0091	R%	+	0.0592
500 nm	Uncert =	0.0098	R%	+	0.2351
550 nm	Uncert =	0.0087	R%	+	0.1777
600 nm	Uncert =	0.0089	R%	+	0.2154
650 nm	Uncert =	0.0087	R%	+	0.1815
700 nm	Uncert =	0.0091	R%	+	0.2301

<= 460 nm Uncert = 0.012 R% + 0.100 (k = 2)

>= 465 nm Uncert = 0.010 R% + 0.250 (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	0.48	0.75
a*	0.12	0.31
b*	0.10	0.47

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0078	R%	+	0.1461
450 nm	Uncert =	0.0064	R%	+	0.0900
500 nm	Uncert =	0.0057	R%	+	0.1324
550 nm	Uncert =	0.0057	R%	+	0.0791
600 nm	Uncert =	0.0056	R%	+	0.1032
650 nm	Uncert =	0.0056	R%	+	0.0831
700 nm	Uncert =	0.0060	R%	+	0.0737

<= 460 nm Uncert = 0.008 R% + 0.150 (k = 2)

>= 460 nm Uncert = 0.006 R% + 0.140 (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	0.28	0.43
a*	0.04	0.19
b*	0.08	0.24

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.15	0.90	0.55	0.56	0.35	0.42	0.42	0.65	0.92	0.52	0.52	0.49	0.32	0.32	0.76
x	< 0.0001	< 0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	< 0.0001
y	< 0.0001	< 0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	< 0.0001
L*	0.48	0.47	0.48	0.47	0.62	0.53	0.54	0.47	0.47	0.48	0.48	0.49	0.74	0.75	0.46
a*	< 0.01	< 0.01	0.04	0.04	0.12	0.21	0.31	0.10	0.16	0.12	0.13	0.04	0.29	0.17	0.02
b*	< 0.01	0.01	0.08	0.08	0.25	0.16	0.17	0.17	0.05	0.10	0.10	0.10	0.47	0.39	0.03

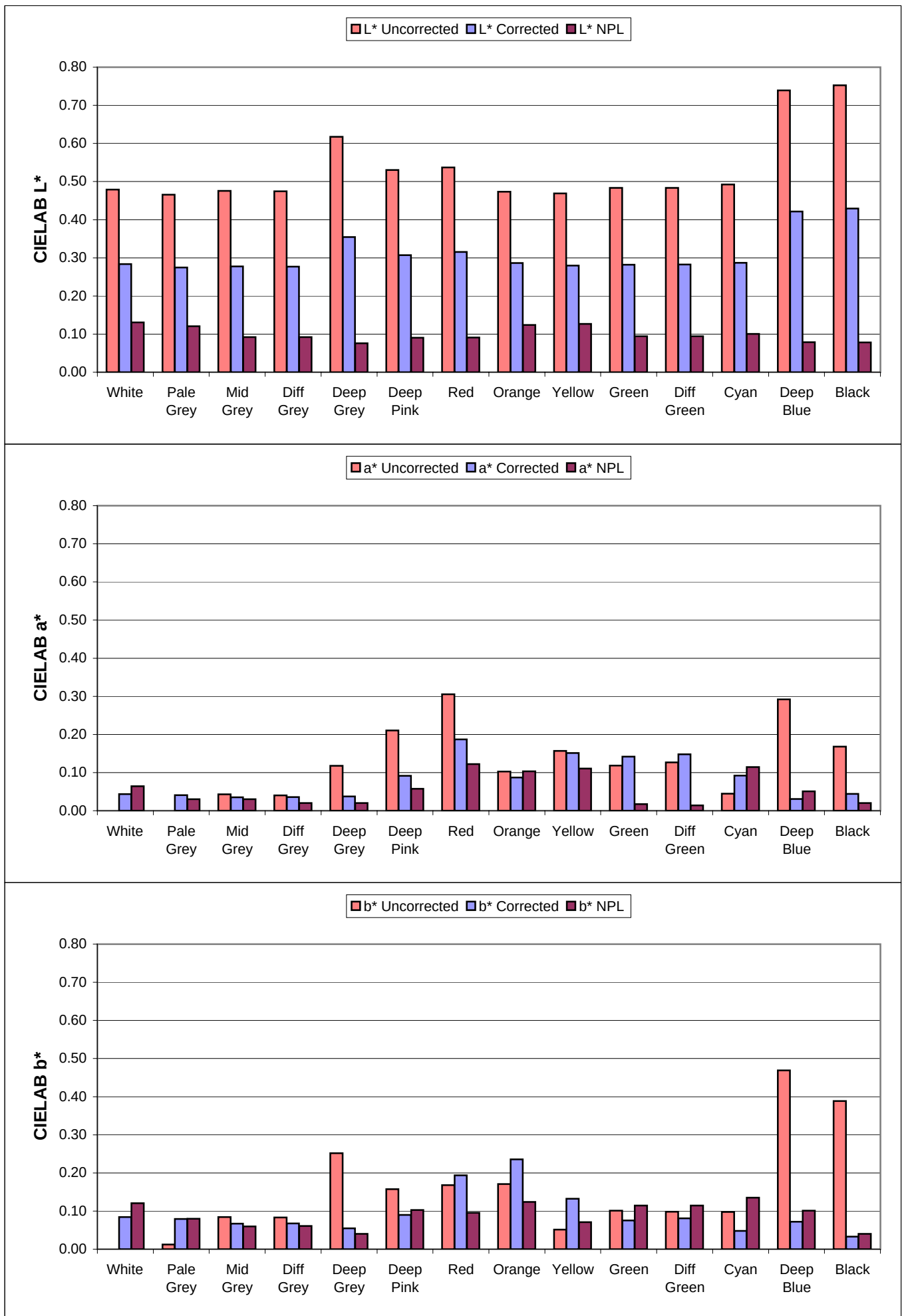
Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

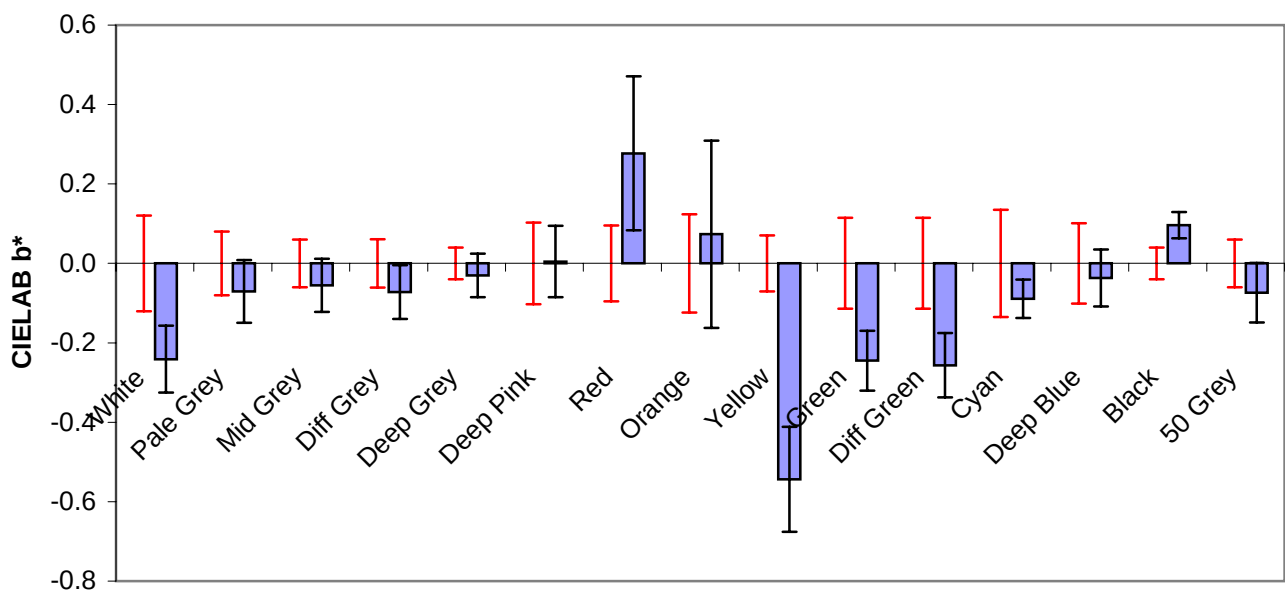
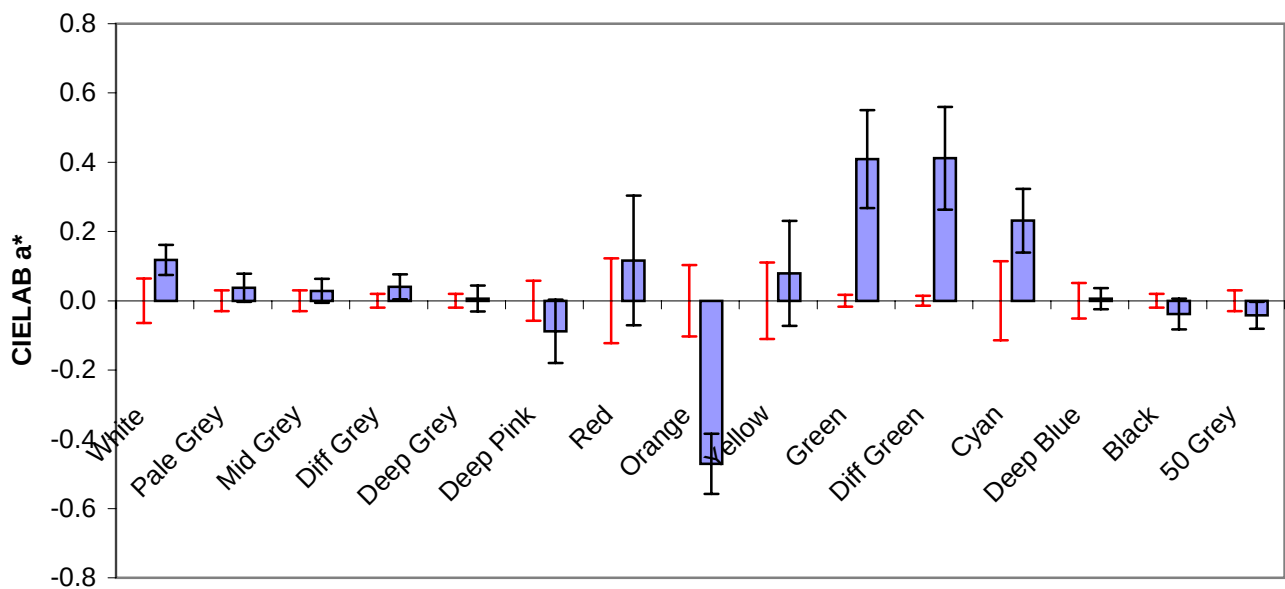
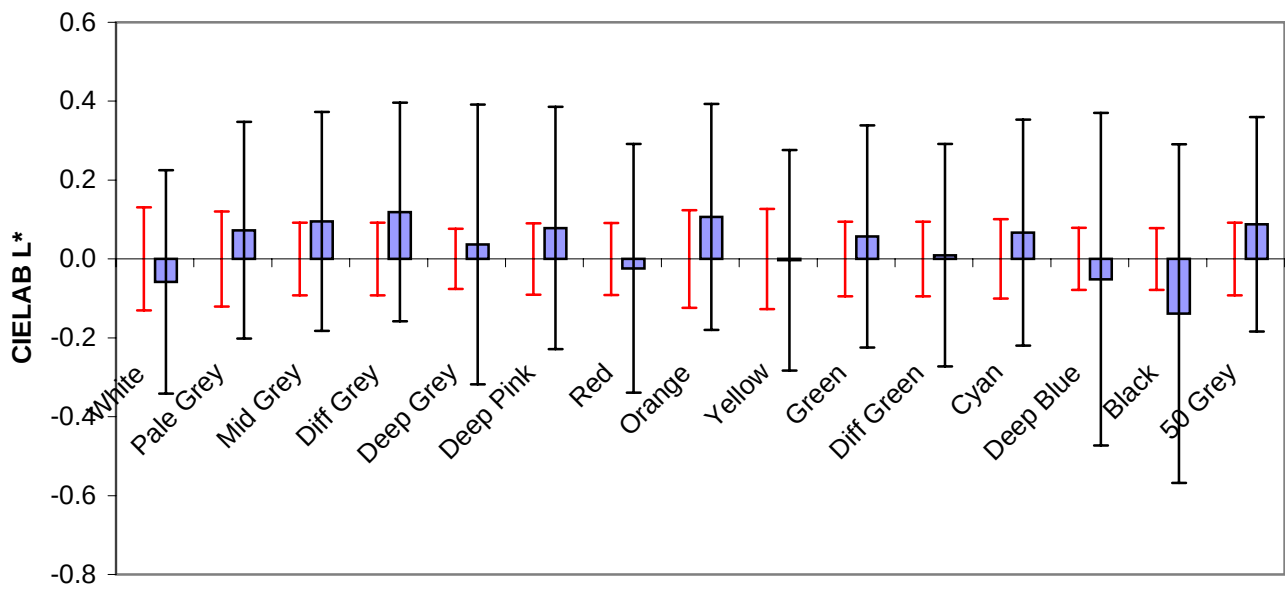
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.68	0.53	0.32	0.33	0.20	0.24	0.25	0.39	0.55	0.30	0.30	0.29	0.18	0.18	0.45
x	< 0.0001	< 0.0001	< 0.0001	0.00	< 0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	< 0.0001
y	0.0002	0.0002	0.0002	0.0002	0.0002	< 0.0001	0.0002	0.0005	0.0005	0.0006	0.0006	0.0001	0.0009	0.0001	0.0002
L*	0.28	0.27	0.28	0.28	0.35	0.31	0.32	0.29	0.28	0.28	0.28	0.29	0.42	0.43	0.27
a*	0.04	0.04	0.03	0.04	0.04	0.09	0.19	0.09	0.15	0.14	0.15	0.09	0.03	0.04	0.04
b*	0.08	0.08	0.07	0.07	0.05	0.09	0.19	0.24	0.13	0.08	0.08	0.05	0.07	0.03	0.08

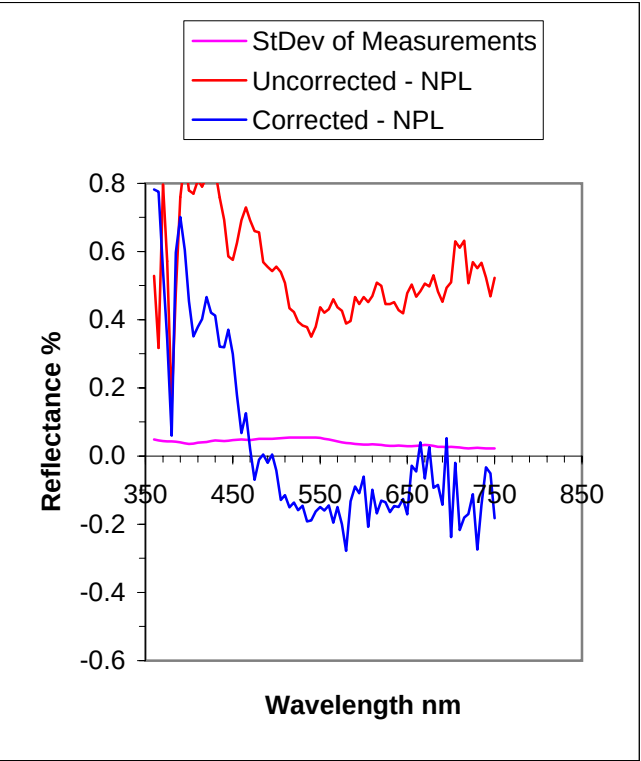
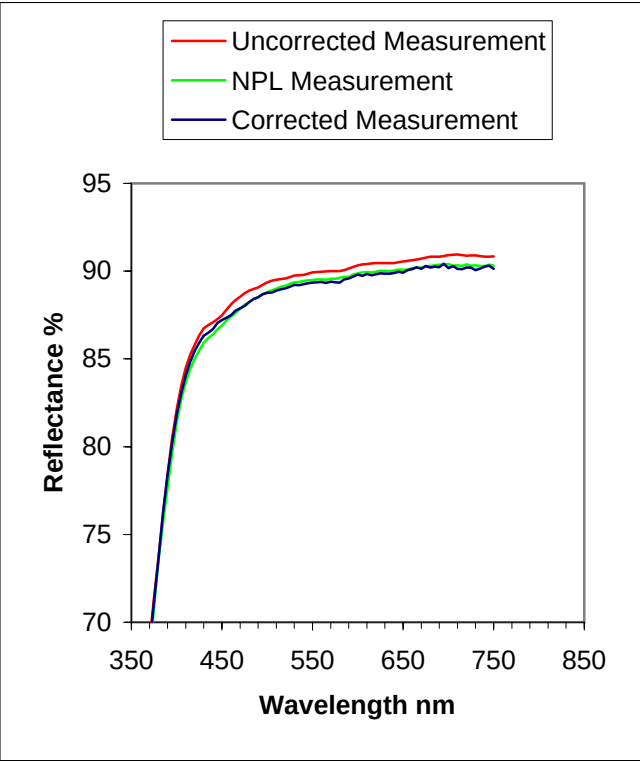
NPL Lambda Uncertainty

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.32	0.23	0.11	0.11	0.04	0.07	0.07	0.17	0.23	0.10	0.09	0.10	0.04	0.03	0.11
x	0.0002	0.0001	0.0001	0.0001	0.0001	0.0003	0.0005	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001
y	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0001	0.0003	0.0002	0.0005	0.0004	0.0004	0.0004	0.0002	0.0002
L*	0.13	0.12	0.09	0.09	0.08	0.09	0.09	0.12	0.13	0.09	0.09	0.10	0.08	0.08	0.09
a*	0.06	0.03	0.03	0.02	0.02	0.06	0.12	0.10	0.11	0.02	0.01	0.11	0.05	0.02	0.03
b*	0.12	0.08	0.06	0.06	0.04	0.10	0.10	0.12	0.07	0.11	0.11	0.13	0.10	0.04	0.06

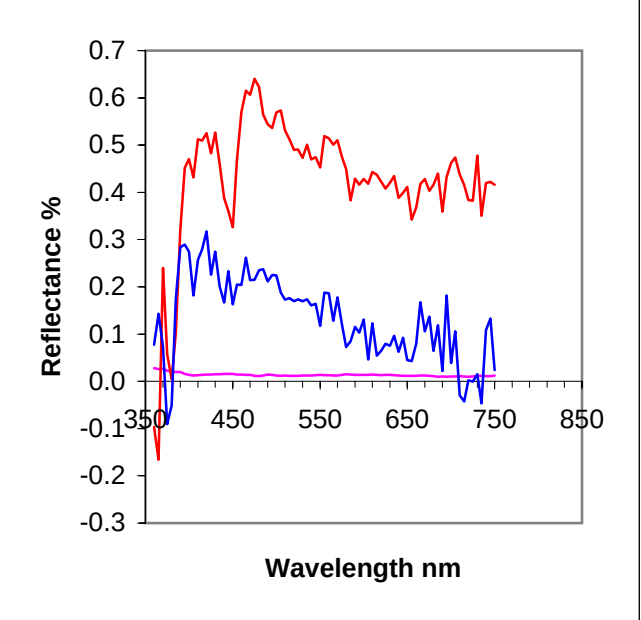
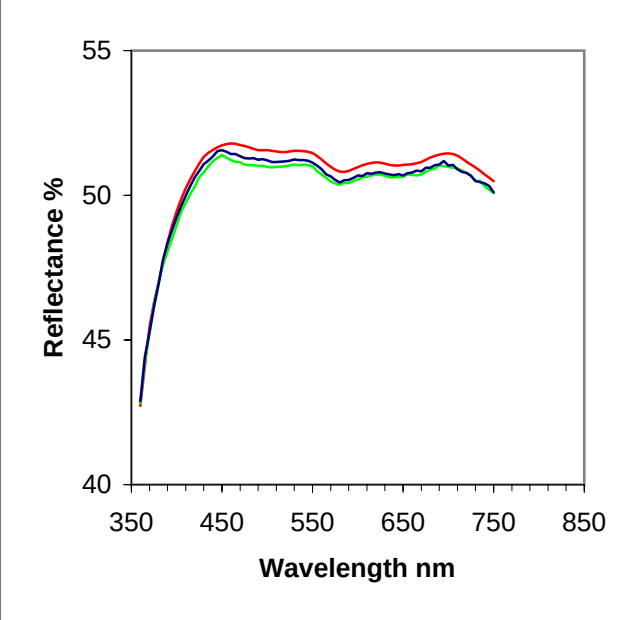
		White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
A	L*	95.92	84.53	62.10	62.66	38.98	48.51	48.19	69.15	85.60	59.01	59.01	56.34	31.68	31.06	76.85
	a*	-0.32	-0.35	-0.25	-1.98	-0.82	22.72	36.54	35.76	-4.73	-27.33	-27.57	-10.23	6.90	-0.85	-0.28
	b*	1.56	0.27	0.04	1.65	-0.77	3.27	15.67	45.68	70.64	10.28	12.73	-28.12	-16.03	-2.37	-0.30
B	L*	95.94	84.53	62.09	62.66	39.00	48.49	48.07	69.09	85.57	59.00	58.99	56.31	31.68	31.05	76.84
	a*	-0.33	-0.35	-0.26	-1.98	-0.82	22.66	36.52	35.80	-4.63	-27.26	-27.53	-10.20	6.90	-0.85	-0.28
	b*	1.56	0.27	0.04	1.65	-0.77	3.24	15.66	45.57	70.65	10.29	12.73	-28.12	-16.03	-2.38	-0.30
C	L*	95.70	84.31	61.92	62.49	38.88	48.35	47.93	68.90	85.35	58.83	58.83	56.16	31.57	30.94	76.64
	a*	-0.30	-0.32	-0.23	-1.95	-0.80	22.63	36.45	35.73	-4.63	-27.19	-27.46	-10.13	6.92	-0.83	-0.25
	b*	1.49	0.21	-0.01	1.60	-0.80	3.19	15.60	45.44	70.48	10.23	12.68	-28.11	-16.04	-2.40	-0.36
D	L*	95.76	84.24	61.83	62.37	38.84	48.27	47.95	68.80	85.35	58.78	58.82	56.09	31.63	31.08	76.55
	a*	-0.42	-0.36	-0.26	-1.99	-0.81	22.71	36.33	36.20	-4.70	-27.60	-27.87	-10.36	6.91	-0.79	-0.21
	b*	1.73	0.28	0.05	1.67	-0.77	3.18	15.32	45.36	71.02	10.48	12.93	-28.02	-16.00	-2.50	-0.28
	dE*	0.029	0.002	0.007	0.005	0.015	0.075	0.125	0.135	0.106	0.074	0.046	0.045	0.002	0.018	0.005
	dE*	0.254	0.228	0.177	0.179	0.125	0.152	0.171	0.241	0.281	0.185	0.186	0.171	0.105	0.106	0.210
	dE*	0.267	0.291	0.265	0.291	0.157	0.232	0.409	0.538	0.434	0.445	0.430	0.294	0.060	0.138	0.298
	dE*	0.275	0.108	0.114	0.145	0.048	0.118	0.301	0.489	0.549	0.480	0.485	0.257	0.064	0.173	0.122
E	L*	95.98	84.58	62.20	62.77	39.23	48.66	48.24	69.19	85.63	59.11	59.11	56.44	32.00	31.37	76.91
	a*	-0.26	-0.28	-0.20	-1.91	-0.77	22.72	36.64	35.81	-4.47	-27.05	-27.31	-10.03	6.95	-0.79	-0.21
	b*	1.58	0.29	0.06	1.67	-0.75	3.28	15.79	45.67	70.61	10.31	12.76	-28.06	-15.96	-2.37	-0.28
F	L*	95.42	84.04	61.65	62.21	38.52	48.04	47.61	68.62	85.07	58.55	58.55	55.87	31.15	30.51	76.37
	a*	-0.34	-0.36	-0.27	-1.99	-0.84	22.53	36.26	35.64	-4.78	-27.33	-27.60	-10.22	6.89	-0.88	-0.29
	b*	1.41	0.13	-0.07	1.53	-0.86	3.10	15.40	45.20	70.35	10.16	12.59	-28.15	-16.11	-2.43	-0.43



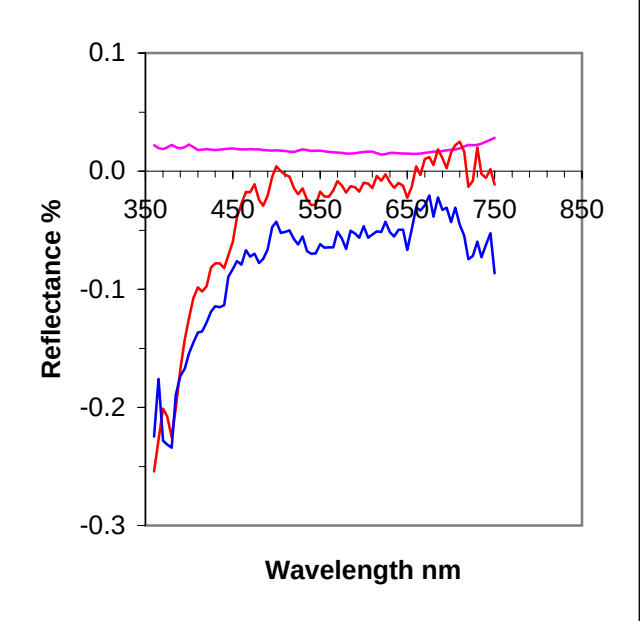
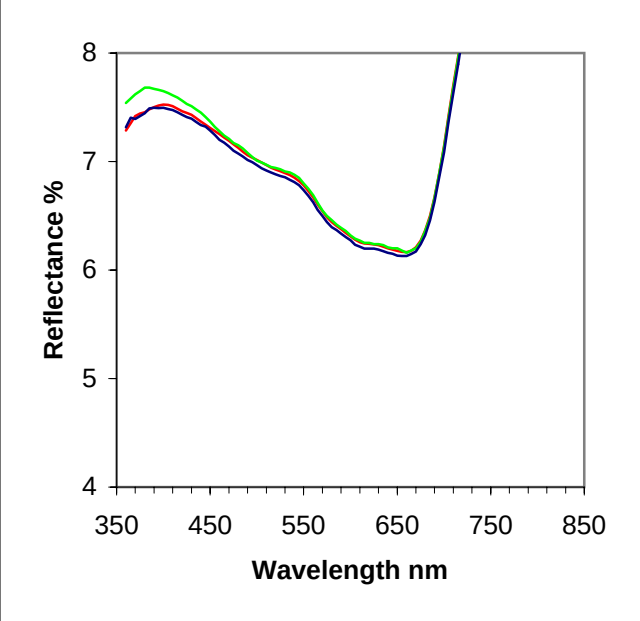




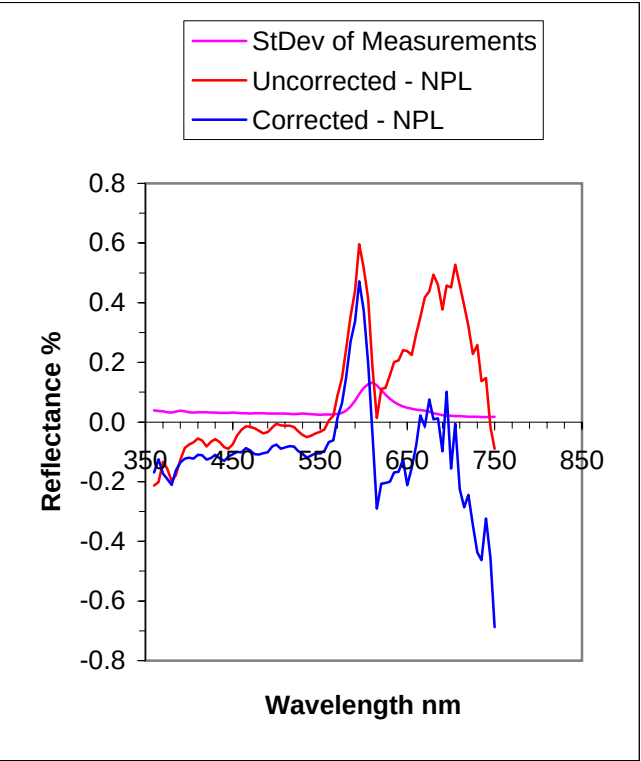
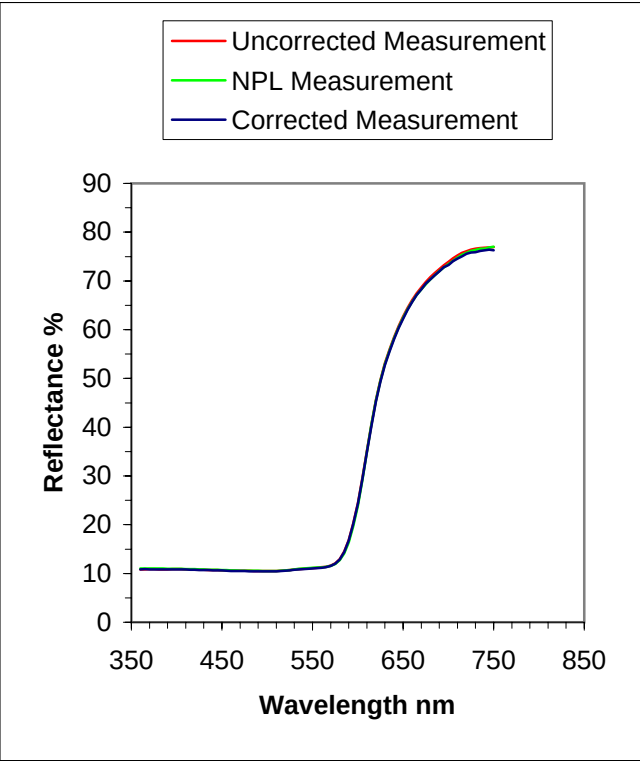
**White
Matt**



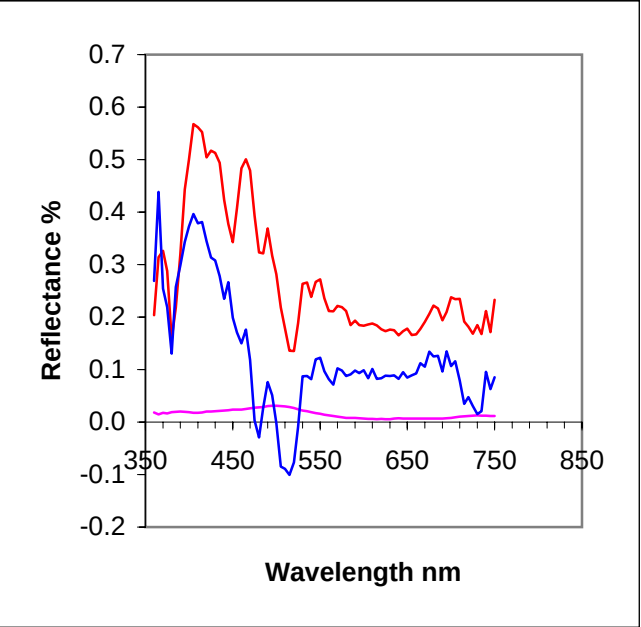
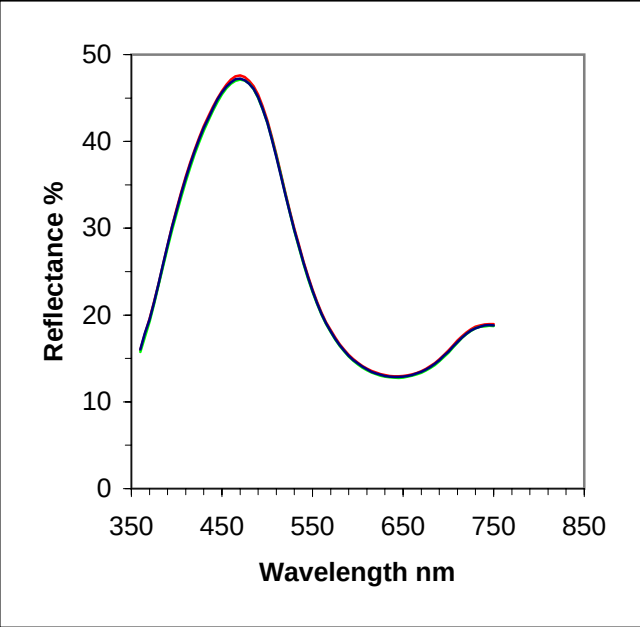
**50 Grey
Matt**



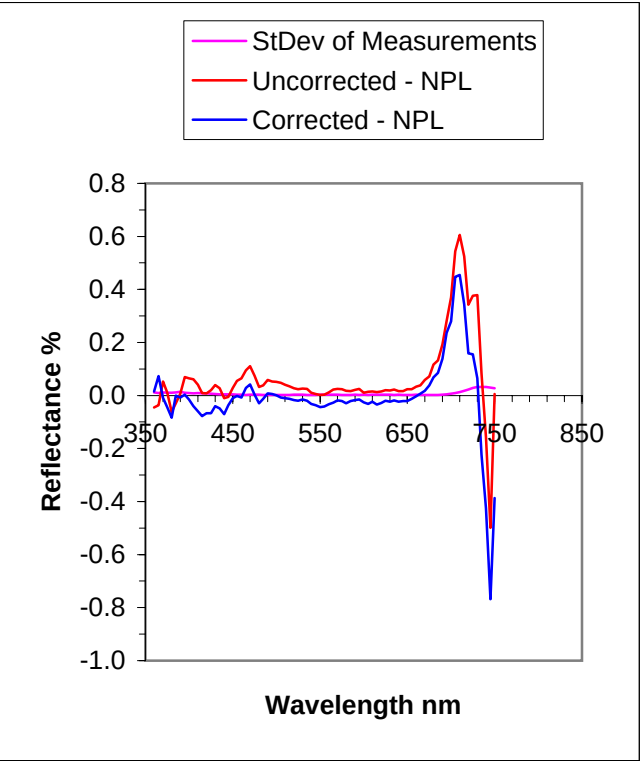
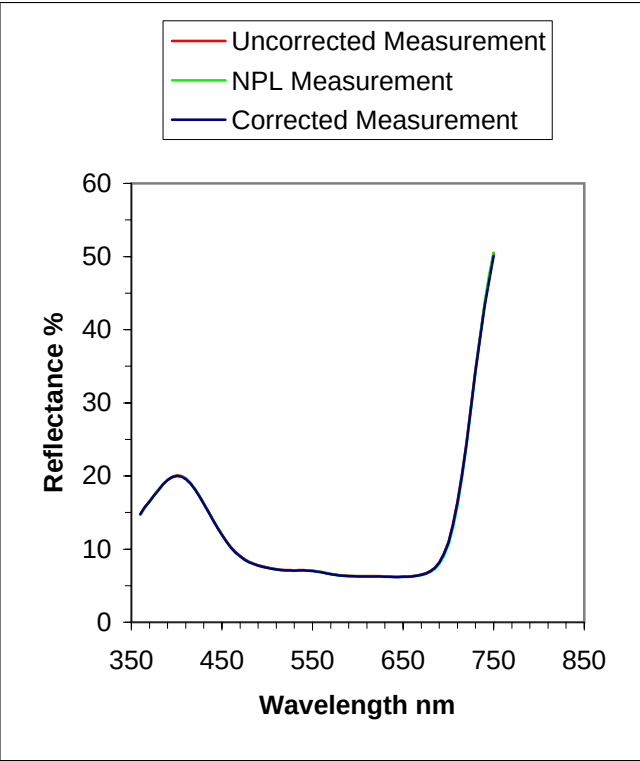
**Black
Matt**



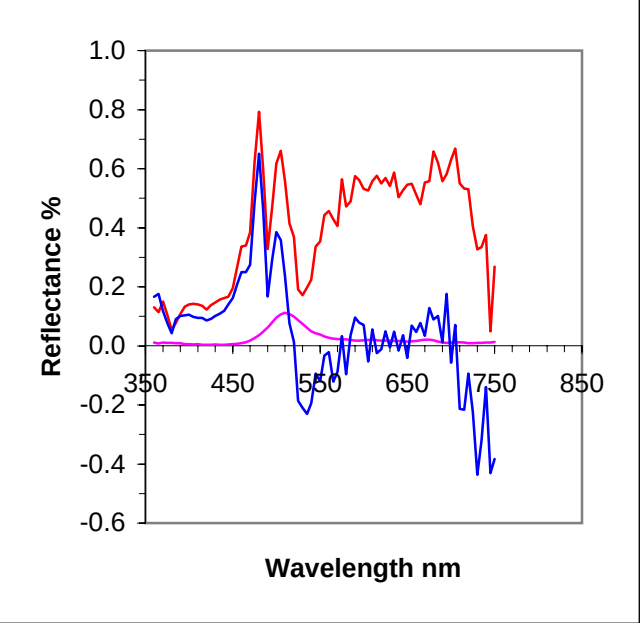
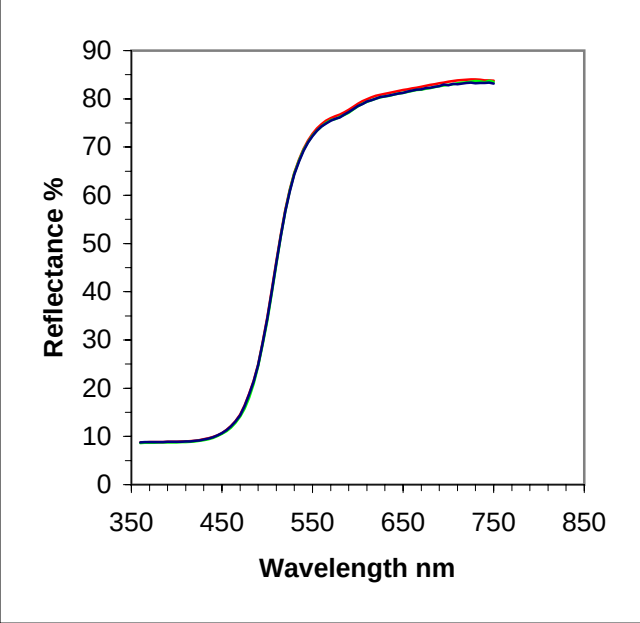
**Red
Matt**



**Cyan
Matt**



**Blue
Matt**



**Yellow
Matt**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 10 mm (Medium)

Geometry: SPIN

Tiles: Matt

NPL Master Tiles: Colours CCM6

White WT45

Black BT10

Grey GT41

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0107	R%	+	0.5547
450 nm	Uncert =	0.0092	R%	+	0.7434
500 nm	Uncert =	0.0084	R%	+	0.6685
550 nm	Uncert =	0.0080	R%	+	0.7256
600 nm	Uncert =	0.0080	R%	+	0.7301
650 nm	Uncert =	0.0082	R%	+	0.7301
700 nm	Uncert =	0.0090	R%	+	0.6689

<= 460 nm Uncert = **0.011** R% + **0.750** (k = 2)

>= 465 nm Uncert = **0.010** R% + **0.750** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	0.96	2.02
a*	0.15	0.82
b*	0.15	1.00

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0079	R%	+	0.7728
450 nm	Uncert =	0.0078	R%	+	0.9055
500 nm	Uncert =	0.0067	R%	+	0.9066
550 nm	Uncert =	0.0077	R%	+	0.9198
600 nm	Uncert =	0.0069	R%	+	0.9448
650 nm	Uncert =	0.0077	R%	+	0.9671
700 nm	Uncert =	0.0085	R%	+	0.9266

<= 460 nm Uncert = **0.008** R% + **1.000** (k = 2)

>= 460 nm Uncert = **0.008** R% + **1.000** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	1.15	2.65
a*	0.16	1.18
b*	0.24	1.46

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.65	1.40	1.06	1.06	0.86	0.92	0.92	1.14	1.42	1.02	1.02	0.99	0.82	0.82	1.26
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0028	0.0064	0.0039	0.0019	0.0010	0.0009	0.0022	0.0040	0.0014	< 0.0001
y	0.0001	< 0.0001	0.0001	0.0002	< 0.0001	0.0006	0.0001	0.0013	0.0022	0.0021	0.0024	0.0017	0.0066	0.0009	< 0.0001
L*	0.69	0.73	0.91	0.90	1.50	1.17	1.19	0.84	0.72	0.96	0.96	1.00	1.95	2.02	0.77
a*	0.02	0.02	0.02	0.04	0.05	0.53	0.82	0.30	0.15	0.52	0.53	0.22	0.47	0.08	0.02
b*	0.04	0.04	0.03	0.05	0.01	0.13	0.59	0.94	1.00	0.21	0.26	0.31	0.87	0.15	0.03

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

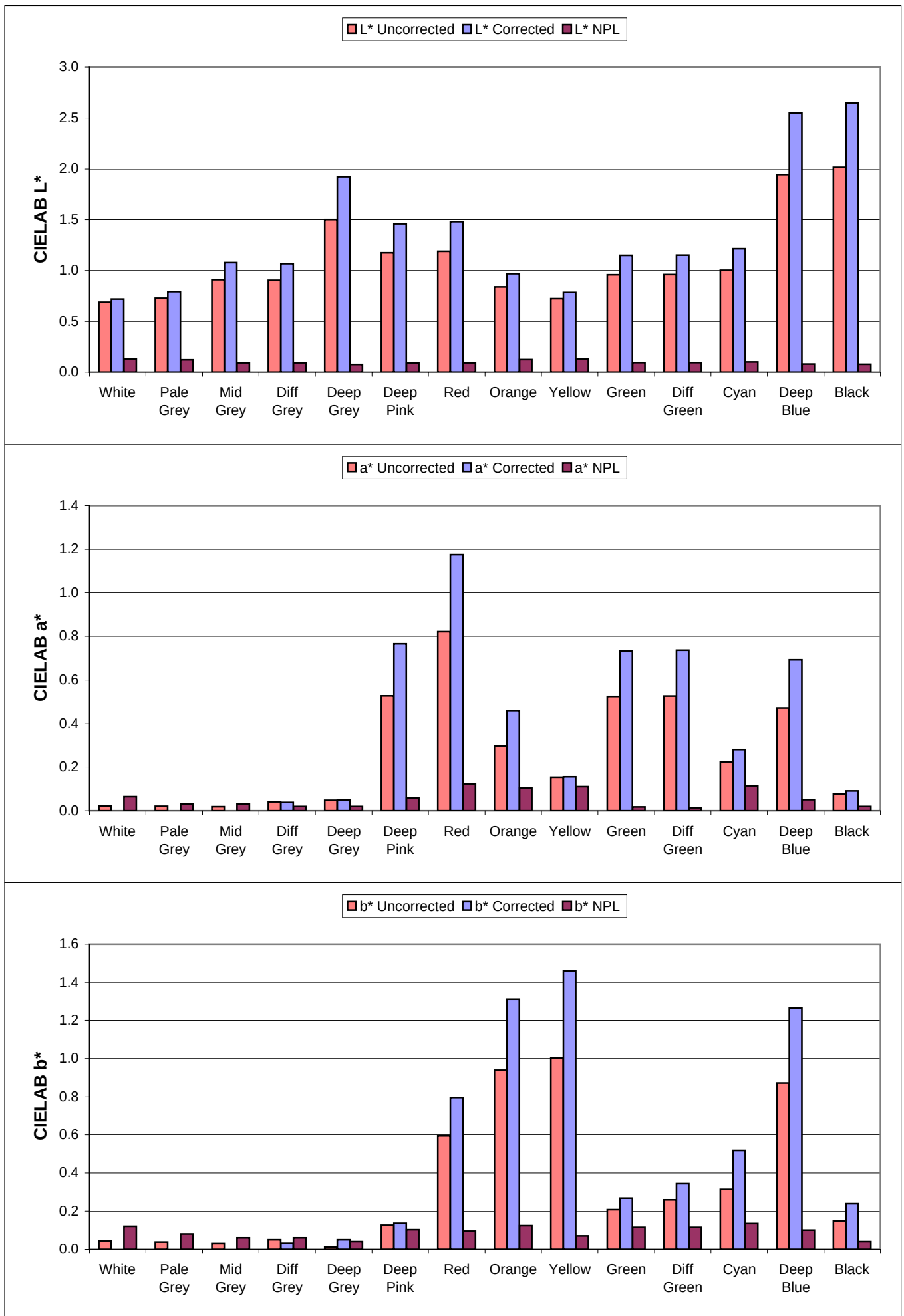
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.71	1.51	1.24	1.25	1.09	1.14	1.14	1.31	1.54	1.21	1.21	1.19	1.06	1.05	1.40
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0005	0.0037	0.0086	0.0052	0.0025	0.0014	0.0012	0.0031	0.0056	0.0020	< 0.0001
y	< 0.0001	< 0.0001	< 0.0001	0.0002	0.0002	0.0010	0.0002	0.0017	0.0030	0.0027	0.0031	0.0024	0.0093	0.0015	< 0.0001
L*	0.72	0.79	1.08	1.07	1.92	1.46	1.48	0.97	0.79	1.15	1.15	1.21	2.55	2.65	0.87
a*	< 0.01	< 0.01	< 0.01	0.04	0.05	0.77	1.18	0.46	0.16	0.73	0.74	0.28	0.69	0.09	< 0.01
b*	< 0.01	< 0.01	< 0.01	0.03	0.05	0.14	0.80	1.31	1.46	0.27	0.34	0.52	1.27	0.24	< 0.01

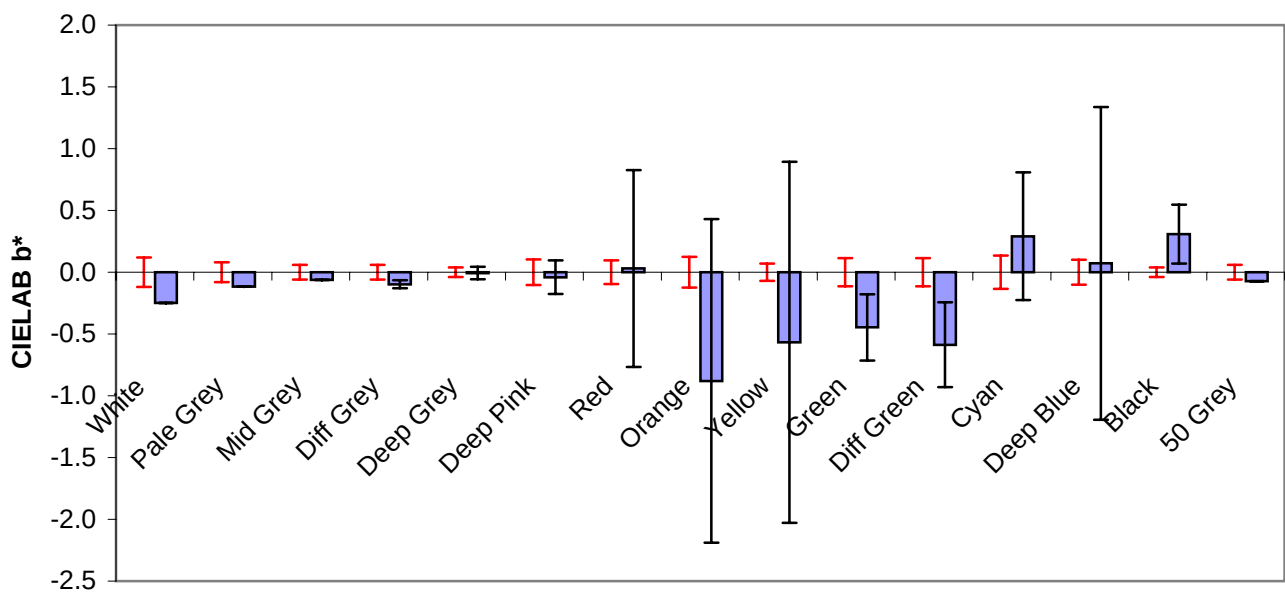
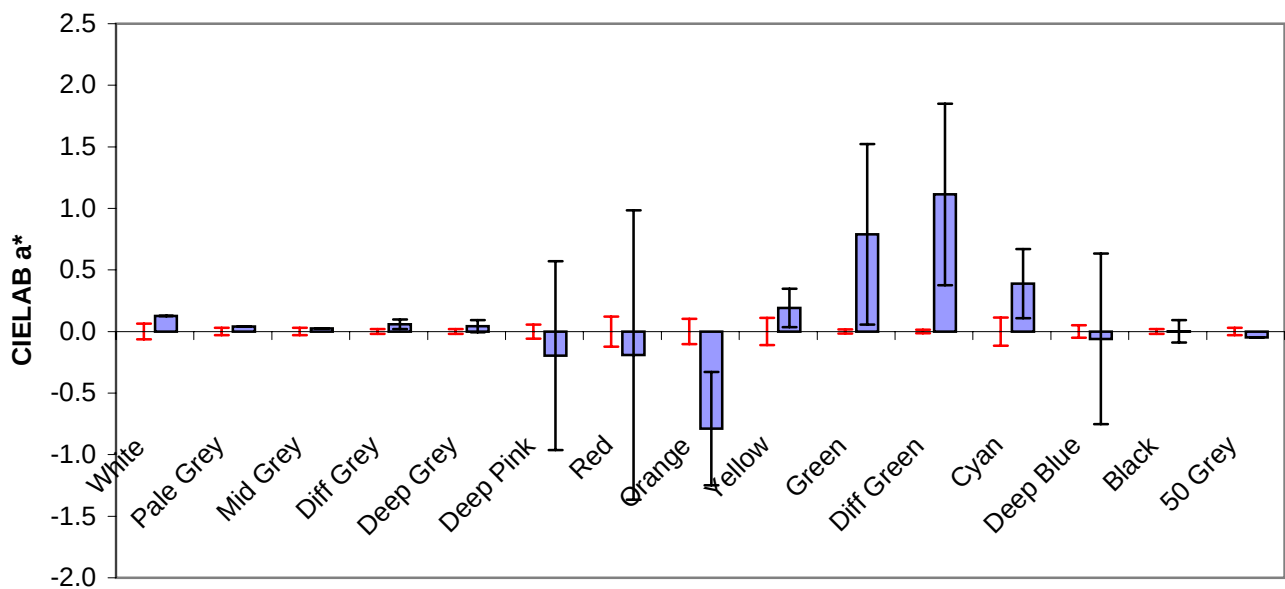
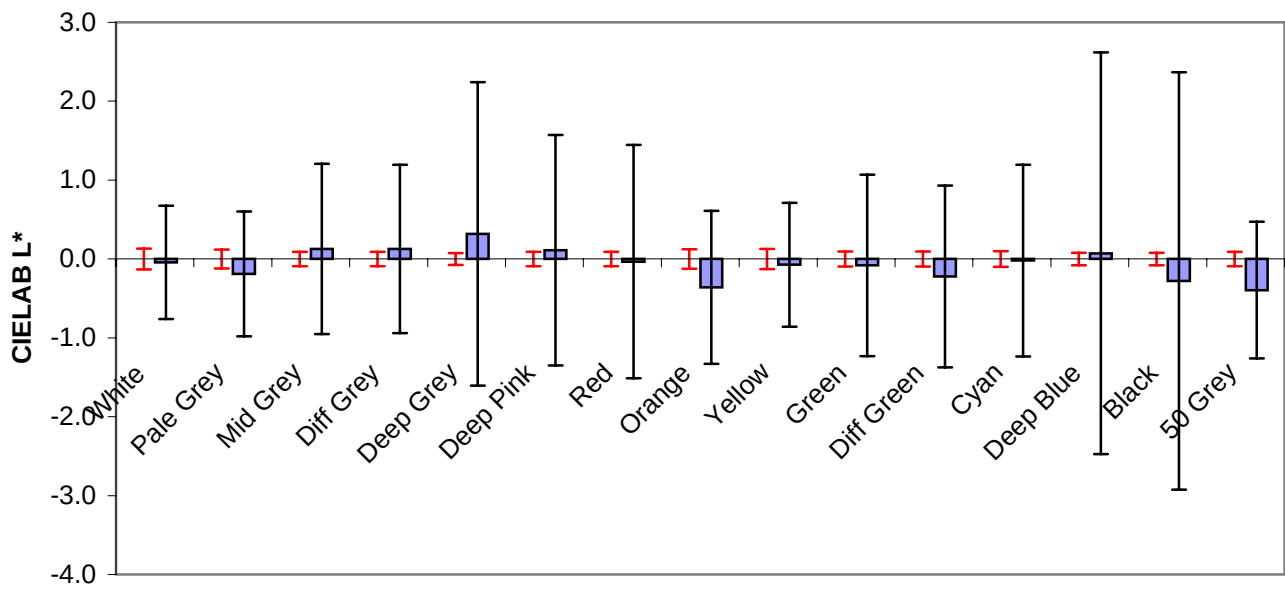
NPL Lambda Uncertainty

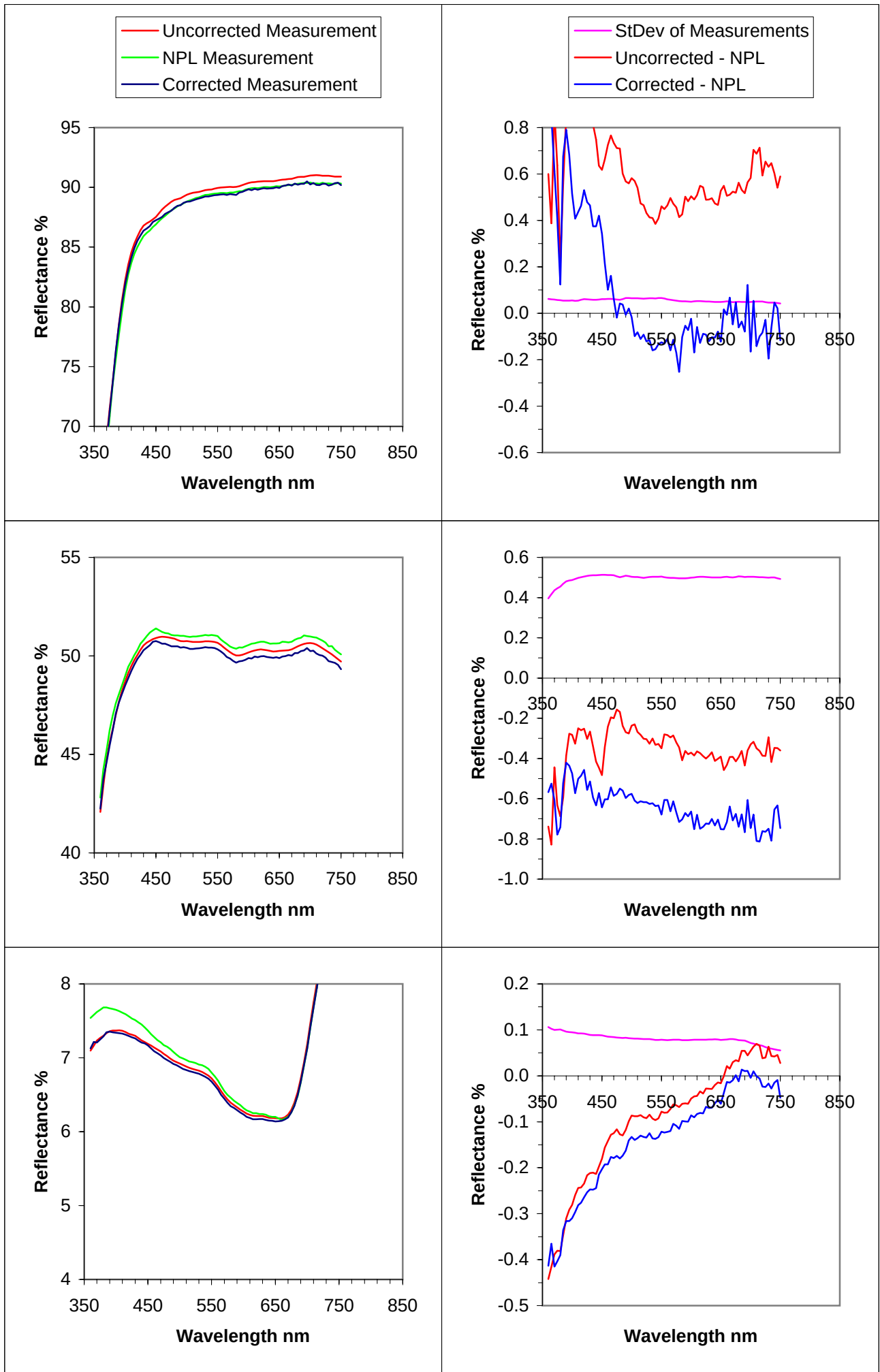
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.32	0.23	0.11	0.11	0.04	0.07	0.07	0.17	0.23	0.10	0.09	0.10	0.04	0.03	0.11
x	0.0002	0.0001	0.0001	0.0001	0.0001	0.0003	0.0005	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001
y	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0001	0.0003	0.0002	0.0005	0.0004	0.0004	0.0004	0.0002	0.0002
L*	0.13	0.12	0.09	0.09	0.08	0.09	0.09	0.12	0.13	0.09	0.09	0.10	0.08	0.08	0.09
a*	0.06	0.03	0.03	0.02	0.02	0.06	0.12	0.10	0.11	0.02	0.01	0.11	0.05	0.02	0.03
b*	0.12	0.08	0.06	0.06	0.04	0.10	0.10	0.12	0.07	0.11	0.11	0.13	0.10	0.04	0.06

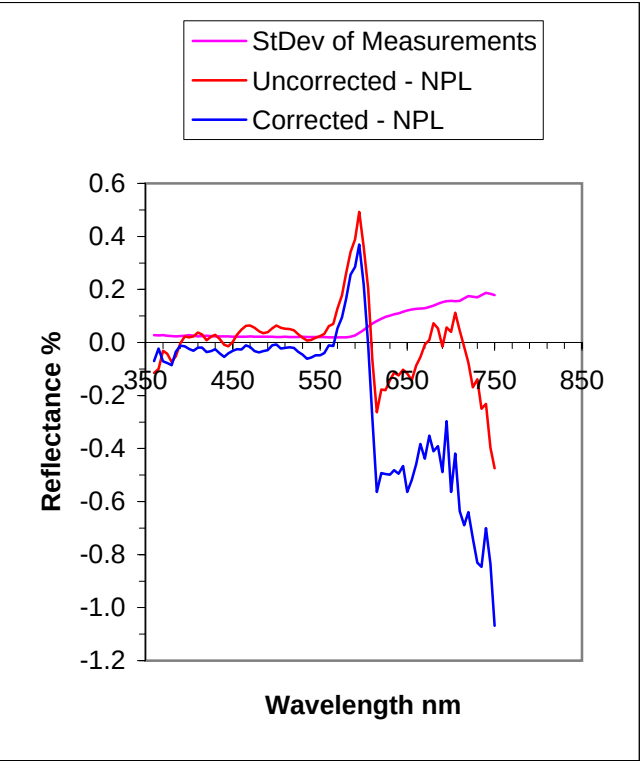
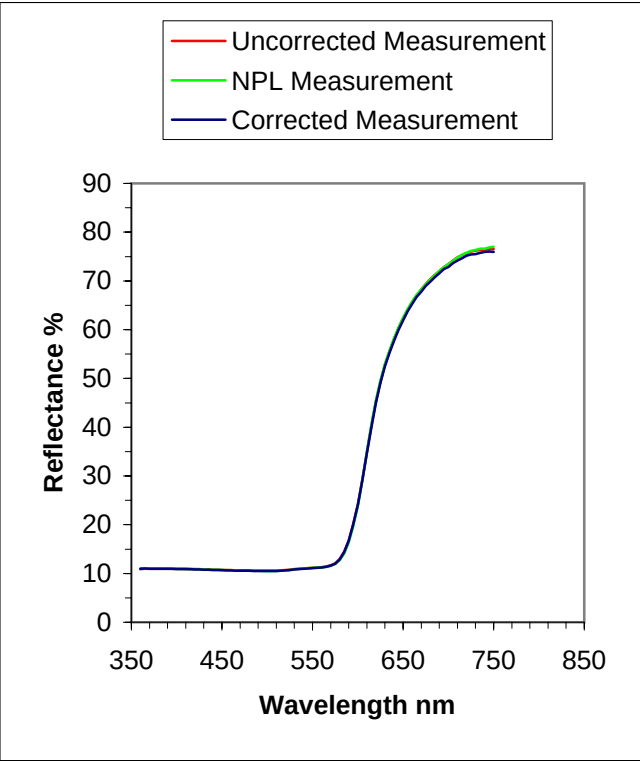
Colorimetry

			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	95.93	84.29	62.16	62.70	39.30	48.53	48.09	69.03	85.52	58.82	58.72	56.19	31.82	30.99	76.72
		a*	-0.31	-0.35	-0.26	-1.96	-0.79	22.54	36.31	35.77	-4.57	-26.82	-26.74	-10.01	6.84	-0.82	-0.28
		b*	1.55	0.23	0.03	1.64	-0.76	3.21	15.48	45.25	70.67	10.00	12.36	-27.74	-15.93	-2.31	-0.31
Average Measurement (Uncorrected)	B	L*	95.96	84.26	62.13	62.67	39.28	48.52	48.05	68.62	85.50	58.86	58.76	56.23	31.80	30.91	76.36
		a*	-0.32	-0.35	-0.26	-1.96	-0.79	22.55	36.21	35.48	-4.52	-26.88	-26.83	-10.04	6.83	-0.81	-0.28
		b*	1.55	0.22	0.03	1.63	-0.75	3.19	15.42	44.62	70.63	10.08	12.40	-27.74	-15.92	-2.16	-0.30
Average Measurement (Corrected)	C	L*	95.72	84.05	61.96	62.50	39.16	48.38	47.92	68.44	85.28	58.70	58.60	56.07	31.70	30.80	76.16
		a*	-0.29	-0.32	-0.23	-1.93	-0.77	22.52	36.14	35.41	-4.51	-26.81	-26.75	-9.97	6.85	-0.79	-0.26
		b*	1.48	0.16	-0.01	1.58	-0.78	3.14	15.35	44.48	70.45	10.03	12.34	-27.73	-15.93	-2.19	-0.36
NPL Values	D	L*	95.76	84.24	61.83	62.37	38.84	48.27	47.95	68.80	85.35	58.78	58.82	56.09	31.63	31.08	76.55
		a*	-0.42	-0.36	-0.26	-1.99	-0.81	22.71	36.33	36.20	-4.70	-27.60	-27.87	-10.36	6.91	-0.79	-0.21
		b*	1.73	0.28	0.05	1.67	-0.77	3.18	15.32	45.36	71.02	10.48	12.93	-28.02	-16.00	-2.50	-0.28
A to B		dE*	0.026	0.025	0.032	0.039	0.024	0.023	0.123	0.806	0.070	0.109	0.102	0.044	0.028	0.167	0.364
B to C		dE*	0.254	0.227	0.177	0.179	0.125	0.152	0.170	0.239	0.281	0.185	0.185	0.170	0.105	0.106	0.209
B to D		dE*	0.284	0.063	0.298	0.302	0.440	0.300	0.187	1.050	0.458	0.822	1.172	0.448	0.207	0.377	0.211
C to D		dE*	0.283	0.226	0.144	0.170	0.322	0.229	0.196	1.235	0.603	0.910	1.278	0.487	0.118	0.415	0.406
Corrected + Uncertainty	E	L*	96.43	84.84	63.04	63.56	41.08	49.84	49.40	69.41	86.06	59.84	59.75	57.28	34.25	33.45	77.02
		a*	-0.29	-0.32	-0.23	-1.89	-0.72	23.28	37.32	35.87	-4.36	-26.07	-26.02	-9.69	7.54	-0.70	-0.25
		b*	1.49	0.16	-0.01	1.61	-0.73	3.28	16.15	45.79	71.91	10.30	12.69	-27.21	-14.66	-1.95	-0.35
Corrected - Uncertainty	F	L*	95.00	83.25	60.88	61.43	37.24	46.92	46.44	67.47	84.49	57.55	57.45	54.86	29.15	28.16	75.29
		a*	-0.29	-0.32	-0.24	-1.97	-0.82	21.75	34.97	34.95	-4.67	-27.54	-27.49	-10.25	6.16	-0.88	-0.26
		b*	1.48	0.16	-0.01	1.55	-0.83	3.01	14.55	43.17	68.99	9.76	12.00	-28.24	-17.19	-2.43	-0.36

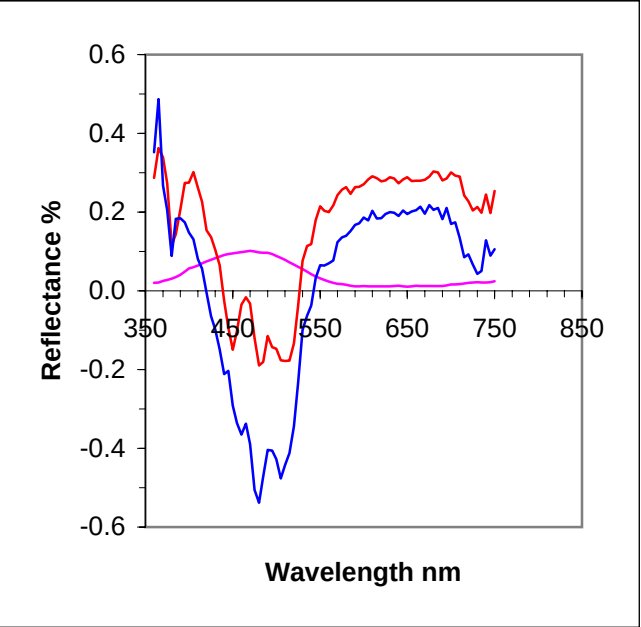
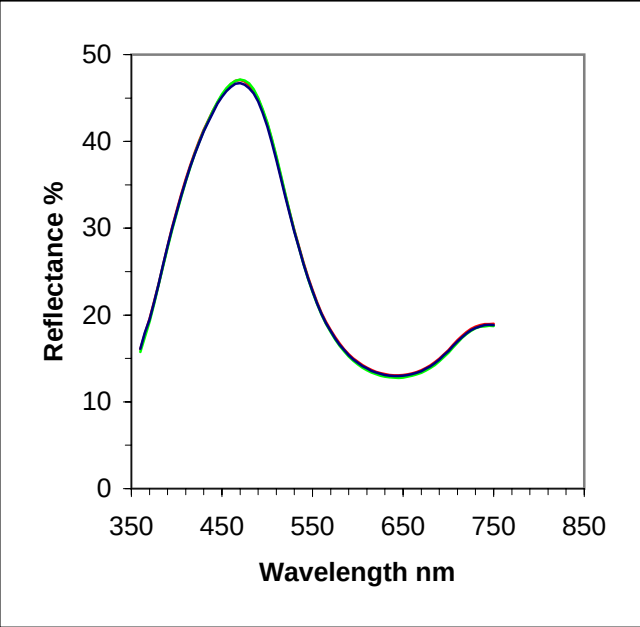




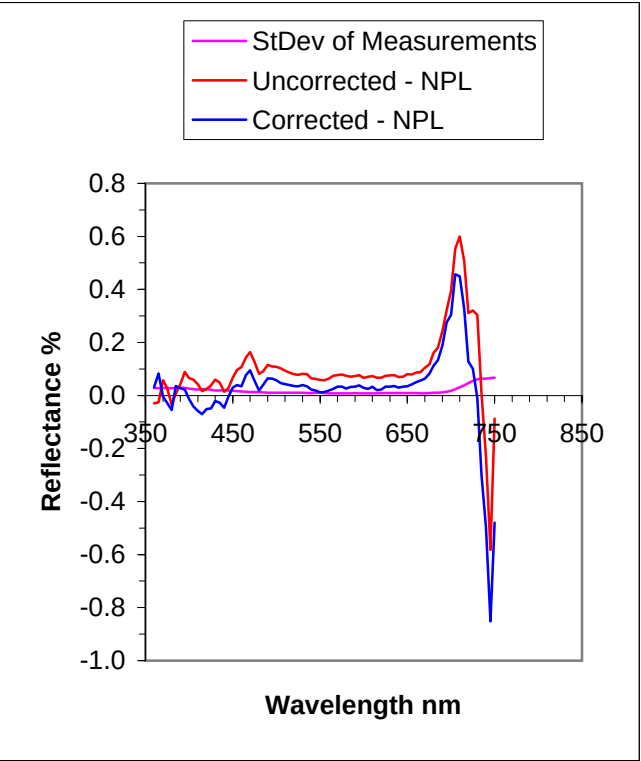
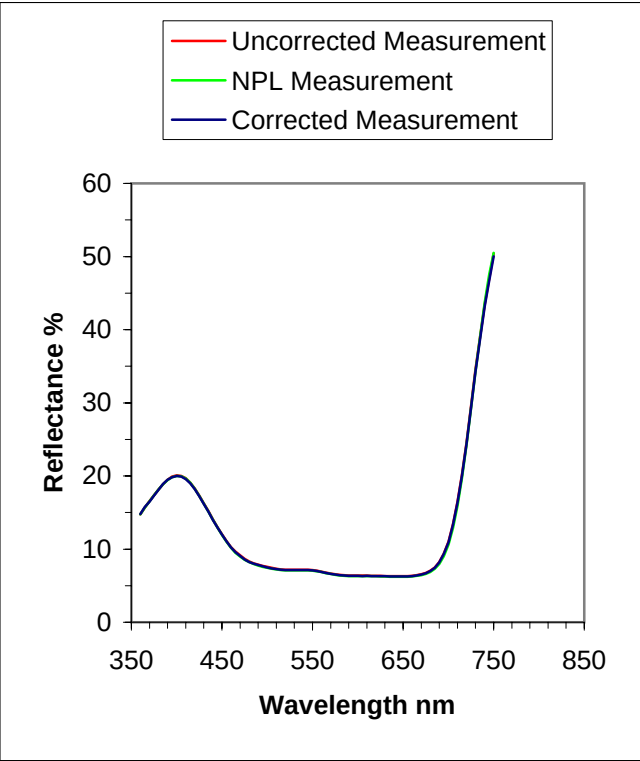




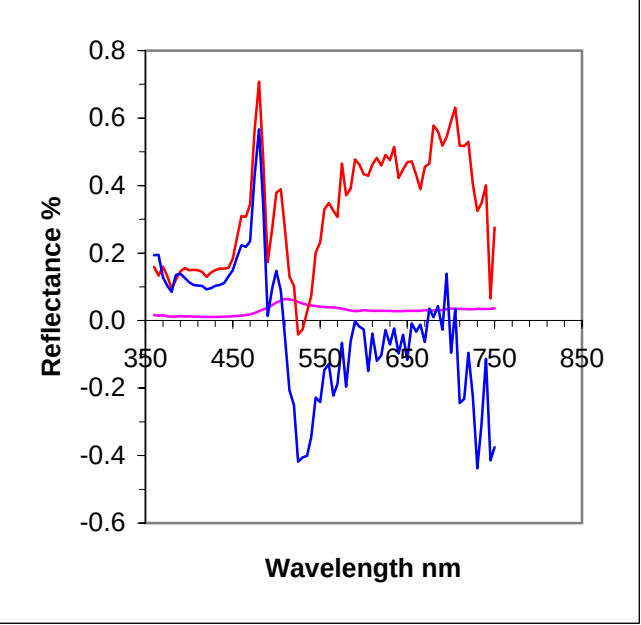
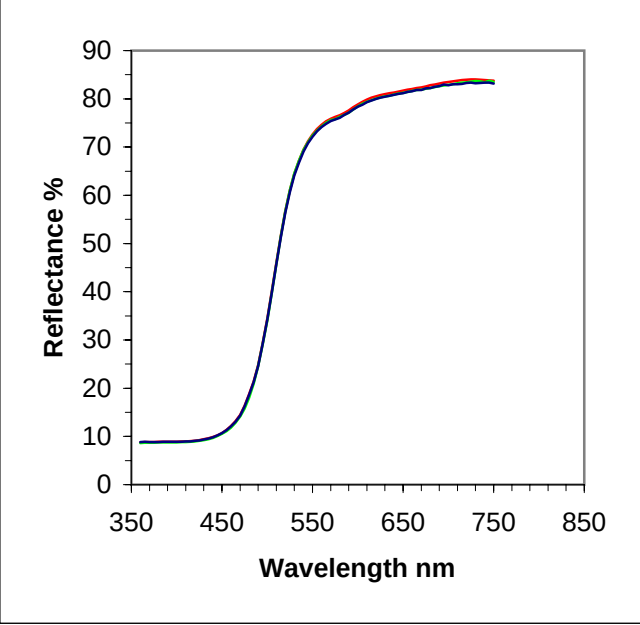
Red
Matt



Cyan
Matt



**Blue
Matt**



**Yellow
Matt**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 3 mm (Small)

Geometry: SPIN

Tiles: Matt

NPL Master Tiles: Colours CCM6

White WT45

Black BT10

Grey GT41

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0071	R%	+	0.4026
450 nm	Uncert =	0.0070	R%	+	0.3785
500 nm	Uncert =	0.0092	R%	+	0.5148
550 nm	Uncert =	0.0078	R%	+	0.5079
600 nm	Uncert =	0.0076	R%	+	0.6208
650 nm	Uncert =	0.0077	R%	+	0.6958
700 nm	Uncert =	0.0088	R%	+	0.8849

<= 460 nm Uncert = **0.008** R% + **0.400** (k = 2)

>= 465 nm Uncert = **0.009** R% + **0.900** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	1.07	2.34
a*	0.30	1.27
b*	0.42	1.98

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0035	R%	+	0.3988
450 nm	Uncert =	0.0044	R%	+	0.3569
500 nm	Uncert =	0.0033	R%	+	0.4924
550 nm	Uncert =	0.0031	R%	+	0.4752
600 nm	Uncert =	0.0027	R%	+	0.5984
650 nm	Uncert =	0.0018	R%	+	0.6679
700 nm	Uncert =	0.0014	R%	+	0.7744

<= 460 nm Uncert = **0.005** R% + **0.400** (k = 2)

>= 460 nm Uncert = **0.004** R% + **0.800** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	0.85	2.01
a*	0.35	1.14
b*	0.35	1.64

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.70	1.48	1.17	1.18	0.99	1.05	1.05	1.24	1.48	1.14	1.14	1.11	0.96	0.95	1.36
x	0.0003	0.0004	0.0008	0.0007	0.0024	0.0015	0.0048	0.0032	0.0015	0.0020	0.0018	0.0030	0.0065	0.0048	0.0005
y	0.0006	0.0008	0.0016	0.0014	0.0044	0.0033	0.0029	0.0004	0.0013	0.0002	0.0002	0.0033	0.0118	0.0082	0.0010
L*	0.71	0.77	1.01	1.00	1.71	1.33	1.35	0.93	0.77	1.07	1.07	1.12	2.25	2.34	0.82
a*	0.14	0.17	0.26	0.23	0.48	0.97	1.27	0.57	0.20	0.30	0.30	0.11	1.23	0.67	0.19
b*	0.27	0.32	0.50	0.48	1.00	0.66	0.36	0.28	0.42	0.40	0.37	0.84	1.98	1.51	0.37

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

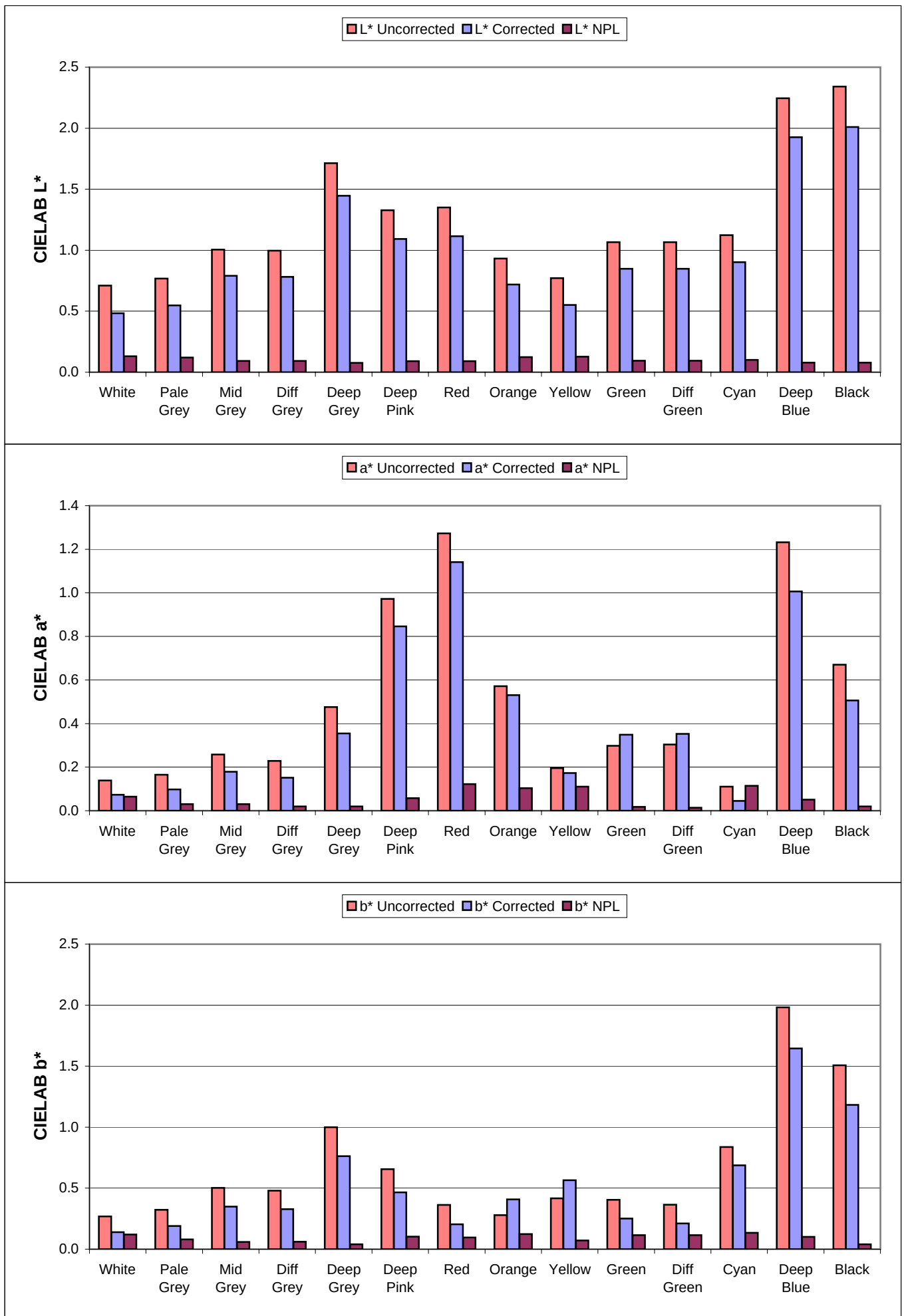
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.15	1.05	0.92	0.92	0.84	0.86	0.86	0.95	1.06	0.90	0.90	0.89	0.82	0.82	1.00
x	0.0001	0.0002	0.0005	0.0005	0.0018	0.0016	0.0046	0.0031	0.0014	0.0017	0.0015	0.0026	0.0054	0.0038	0.0003
y	0.0003	0.0005	0.0011	0.0010	0.0034	0.0026	0.0022	0.0004	0.0013	0.0003	0.0005	0.0027	0.0099	0.0064	0.0006
L*	0.48	0.55	0.79	0.78	1.45	1.09	1.11	0.72	0.55	0.85	0.85	0.90	1.93	2.01	0.61
a*	0.07	0.10	0.18	0.15	0.35	0.85	1.14	0.53	0.17	0.35	0.35	0.04	1.01	0.51	0.12
b*	0.14	0.19	0.35	0.33	0.76	0.47	0.20	0.41	0.57	0.25	0.21	0.69	1.64	1.18	0.24

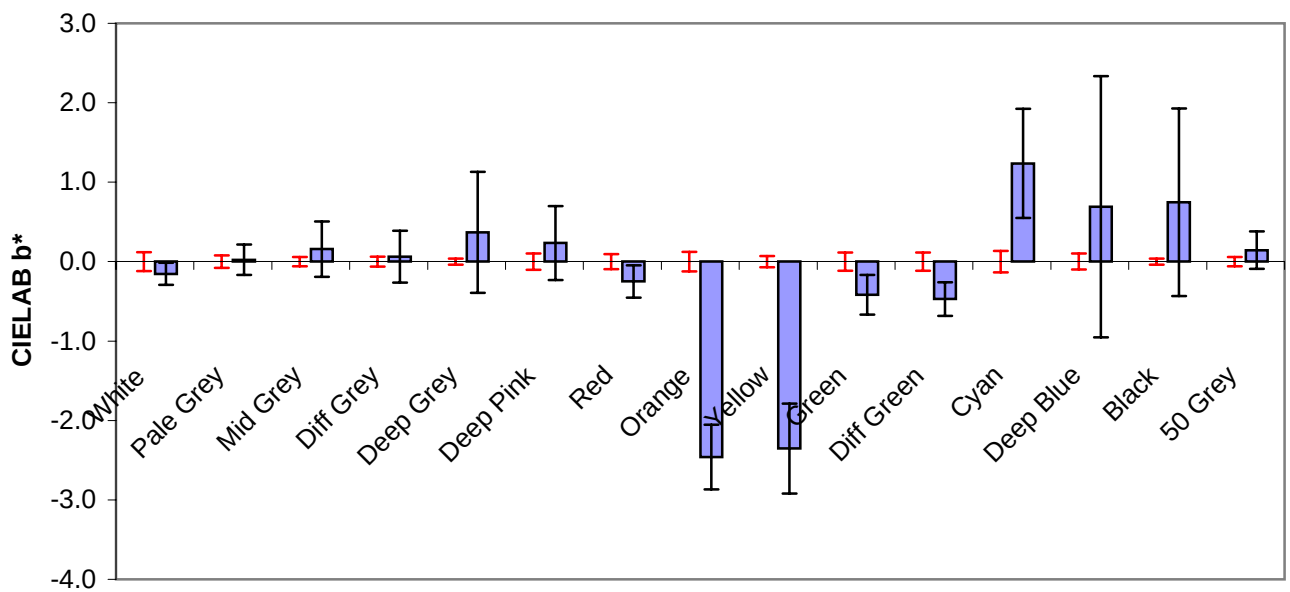
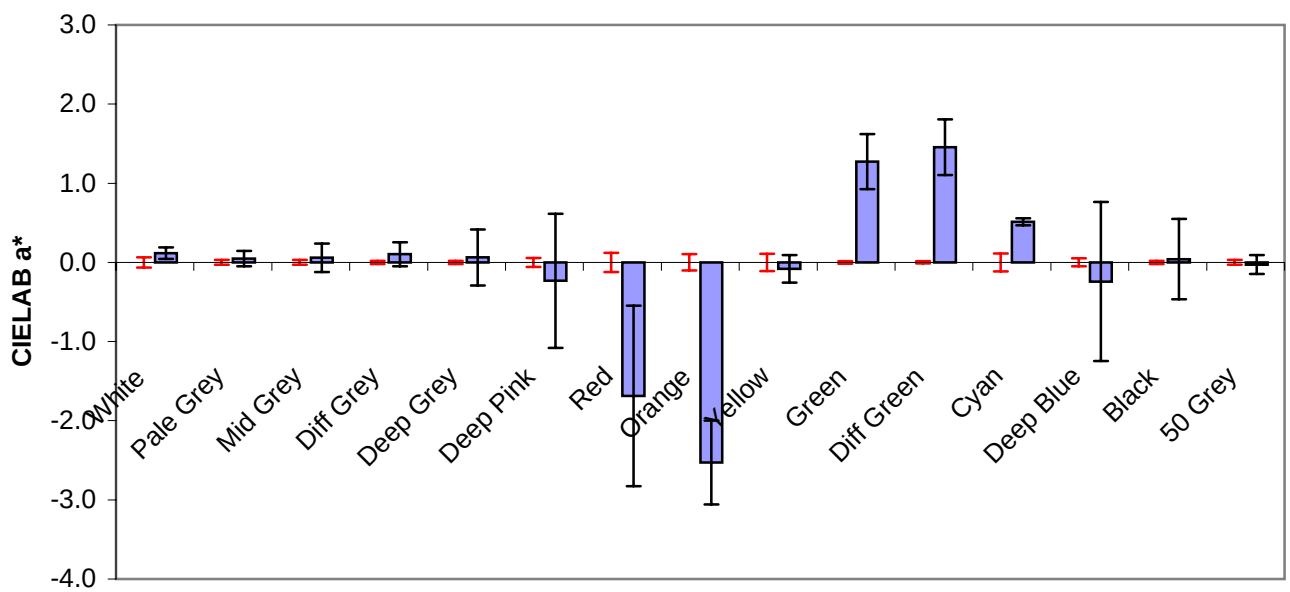
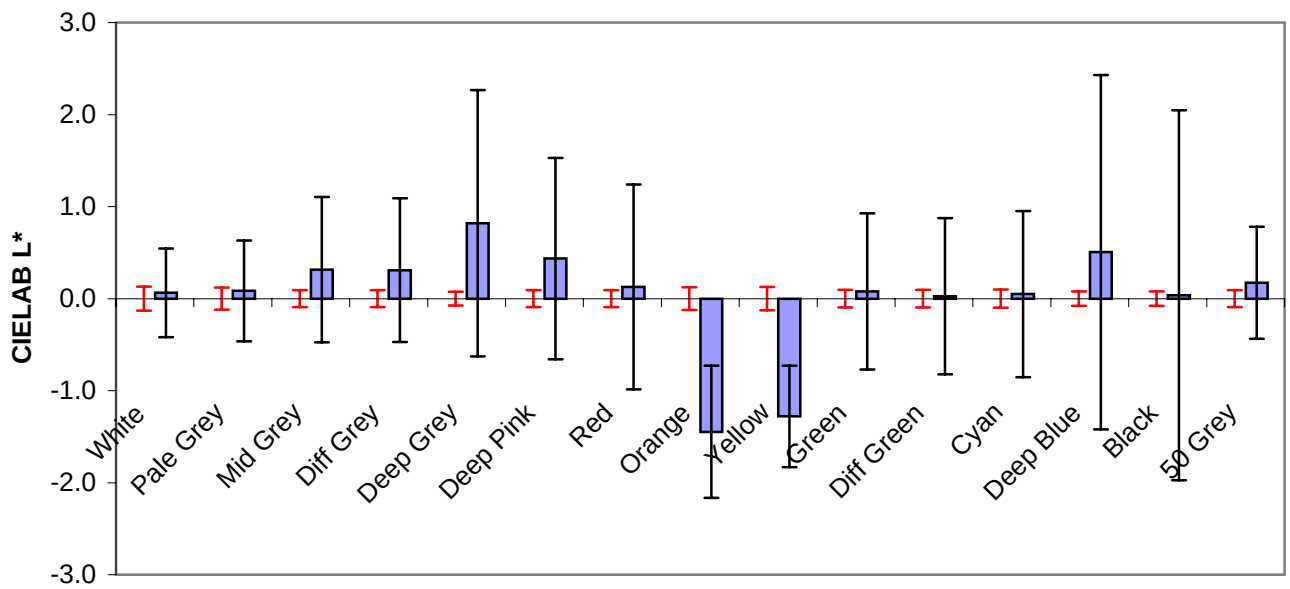
NPL Lambda Uncertainty

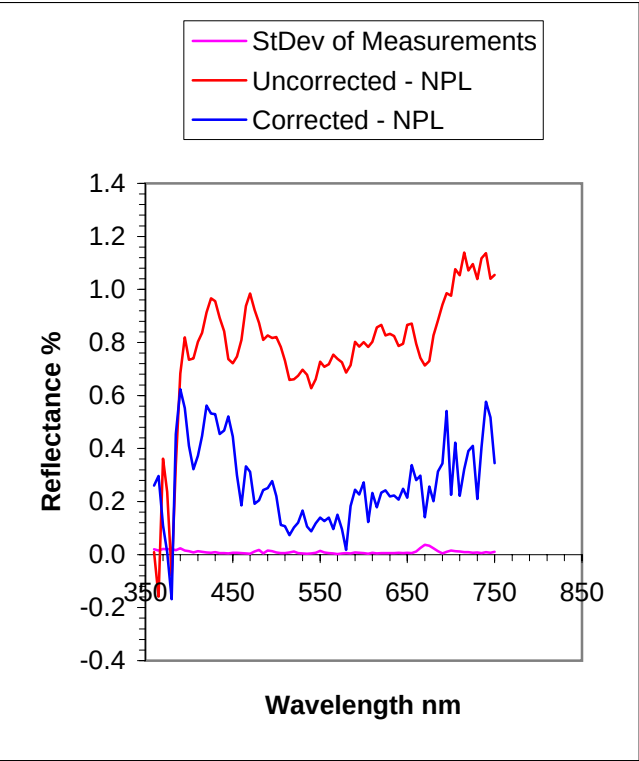
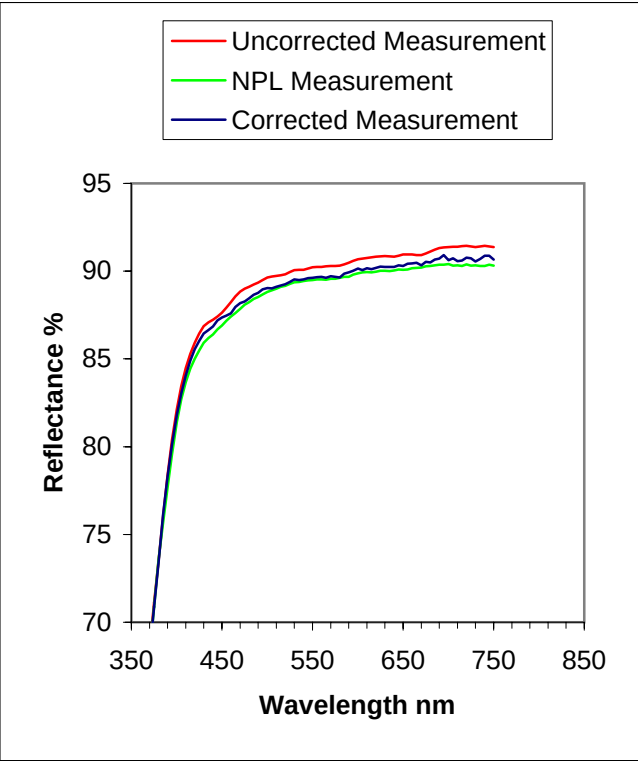
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.32	0.23	0.11	0.11	0.04	0.07	0.07	0.17	0.23	0.10	0.09	0.10	0.04	0.03	0.11
x	0.0002	0.0001	0.0001	0.0001	0.0001	0.0003	0.0005	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001
y	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0001	0.0003	0.0002	0.0005	0.0004	0.0004	0.0004	0.0002	0.0002
L*	0.13	0.12	0.09	0.09	0.08	0.09	0.09	0.12	0.13	0.09	0.09	0.10	0.08	0.08	0.09
a*	0.06	0.03	0.03	0.02	0.02	0.06	0.12	0.10	0.11	0.02	0.01	0.11	0.05	0.02	0.03
b*	0.12	0.08	0.06	0.06	0.04	0.10	0.10	0.12	0.07	0.11	0.11	0.13	0.10	0.04	0.06

Colorimetry

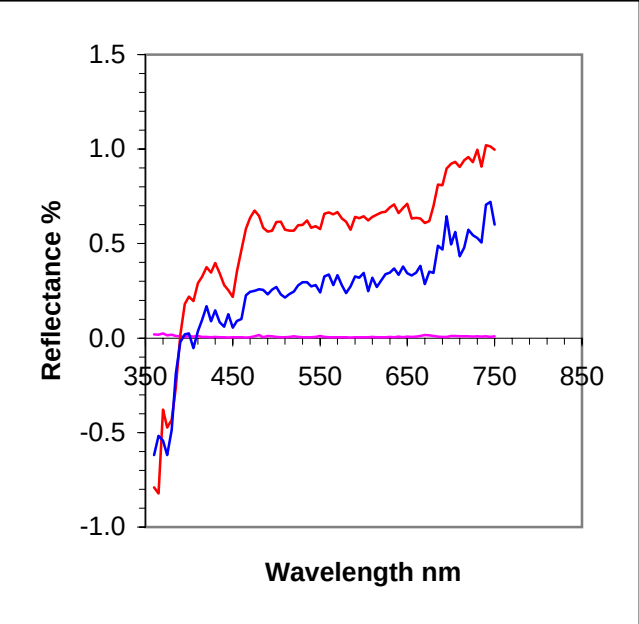
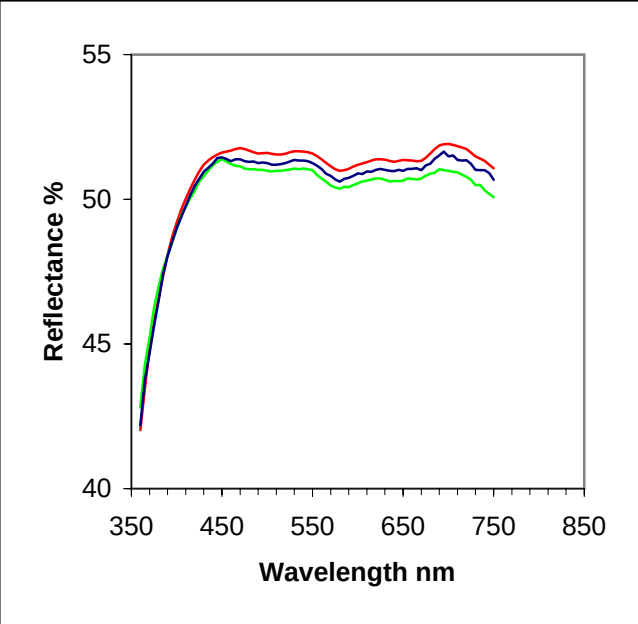
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	96.07	84.54	62.32	62.85	39.78	48.86	48.23	67.56	84.33	59.03	59.02	56.30	32.22	31.21	76.93
		a*	-0.33	-0.34	-0.22	-1.91	-0.77	22.54	34.77	33.72	-4.83	-26.44	-26.52	-9.93	6.67	-0.76	-0.27
		b*	1.65	0.36	0.25	1.78	-0.37	3.48	15.17	43.10	68.88	10.11	12.52	-26.79	-15.30	-1.74	-0.08
Average Measurement (Uncorrected)	B	L*	96.07	84.54	62.31	62.85	39.78	48.85	48.22	67.53	84.29	59.02	59.01	56.30	32.24	31.22	76.93
		a*	-0.33	-0.34	-0.22	-1.91	-0.76	22.51	34.72	33.74	-4.79	-26.40	-26.48	-9.91	6.65	-0.77	-0.26
		b*	1.65	0.36	0.25	1.79	-0.38	3.47	15.14	43.03	68.84	10.11	12.52	-26.79	-15.30	-1.72	-0.08
Average Measurement (Corrected)	C	L*	95.82	84.32	62.14	62.68	39.66	48.71	48.08	67.35	84.07	58.85	58.85	56.14	32.13	31.12	76.72
		a*	-0.30	-0.31	-0.20	-1.89	-0.75	22.48	34.65	33.67	-4.79	-26.32	-26.41	-9.85	6.67	-0.75	-0.24
		b*	1.58	0.30	0.20	1.74	-0.41	3.42	15.07	42.90	68.67	10.06	12.46	-26.78	-15.31	-1.75	-0.14
NPL Values	D	L*	95.76	84.24	61.83	62.37	38.84	48.27	47.95	68.80	85.35	58.78	58.82	56.09	31.63	31.08	76.55
		a*	-0.42	-0.36	-0.26	-1.99	-0.81	22.71	36.33	36.20	-4.70	-27.60	-27.87	-10.36	6.91	-0.79	-0.21
		b*	1.73	0.28	0.05	1.67	-0.77	3.18	15.32	45.36	71.02	10.48	12.93	-28.02	-16.00	-2.50	-0.28
A to B		dE*	0.002	0.002	0.004	0.006	0.003	0.032	0.066	0.074	0.071	0.045	0.043	0.021	0.019	0.018	0.004
B to C		dE*	0.254	0.228	0.178	0.180	0.126	0.153	0.169	0.234	0.277	0.185	0.185	0.170	0.106	0.107	0.211
B to D		dE*	0.329	0.314	0.528	0.498	1.022	0.673	1.650	3.618	2.428	1.279	1.457	1.323	0.964	0.786	0.427
C to D		dE*	0.204	0.100	0.358	0.332	0.899	0.546	1.709	3.813	2.679	1.342	1.529	1.339	0.890	0.750	0.226
Corrected + Uncertainty	E	L*	96.31	84.87	62.93	63.46	41.11	49.80	49.19	68.07	84.63	59.70	59.69	57.04	34.06	33.13	77.33
		a*	-0.23	-0.21	-0.02	-1.74	-0.39	23.33	35.79	34.20	-4.61	-25.98	-26.06	-9.80	7.67	-0.25	-0.12
		b*	1.72	0.49	0.55	2.07	0.35	3.88	15.27	43.31	69.23	10.31	12.67	-26.09	-13.66	-0.57	0.10
Corrected - Uncertainty	F	L*	95.34	83.77	61.36	61.90	38.21	47.62	46.96	66.63	83.52	58.01	58.00	55.24	30.21	29.11	76.12
		a*	-0.37	-0.41	-0.38	-2.04	-1.10	21.63	33.51	33.14	-4.96	-26.67	-26.77	-9.89	5.66	-1.26	-0.36
		b*	1.44	0.11	-0.14	1.41	-1.17	2.95	14.87	42.49	68.10	9.81	12.25	-27.47	-16.95	-2.93	-0.37



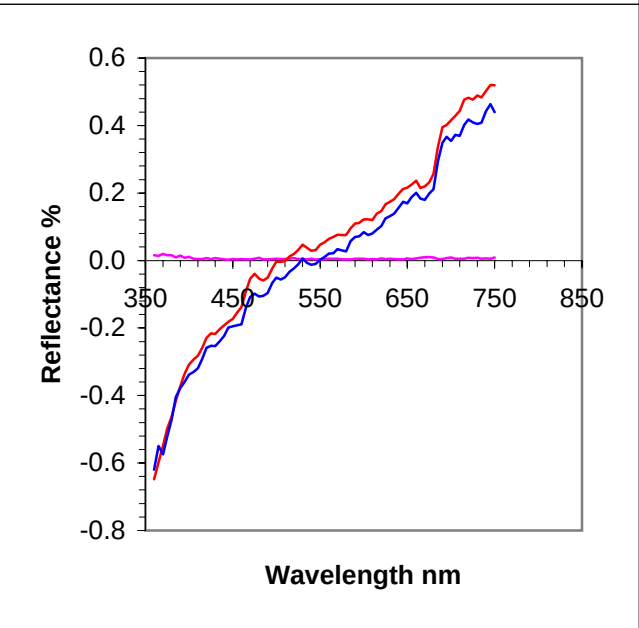
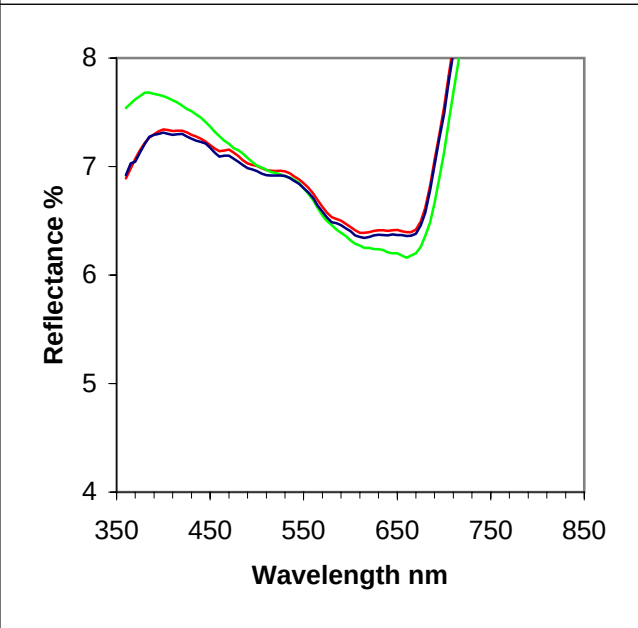




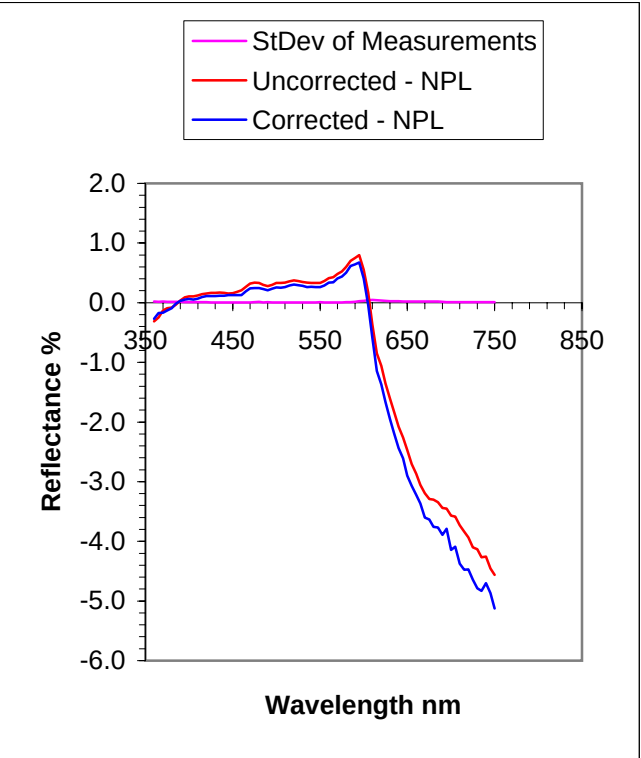
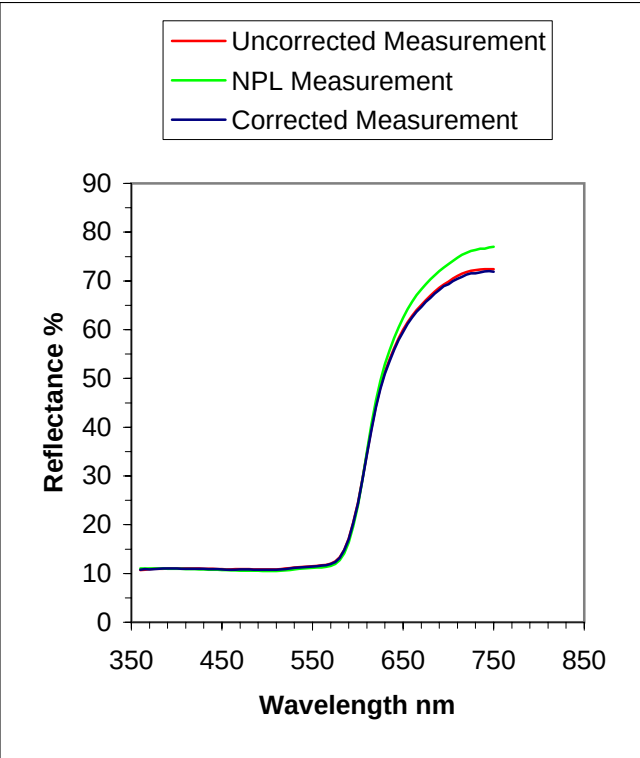
**White
Matt**



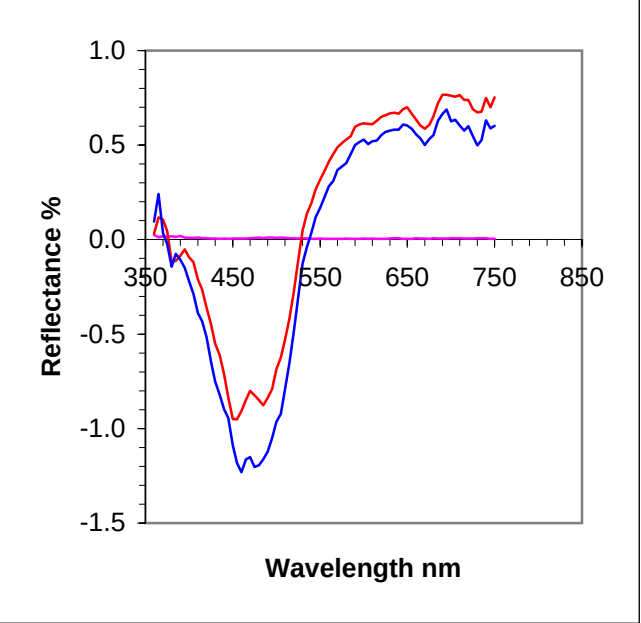
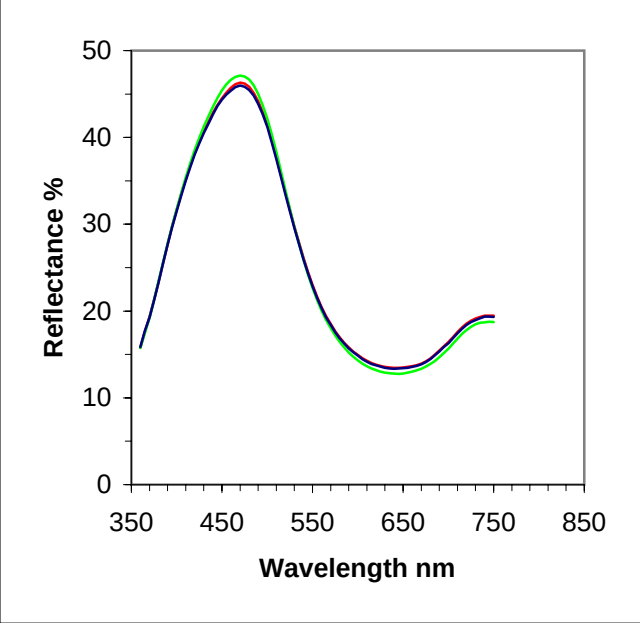
**50 Grey
Matt**



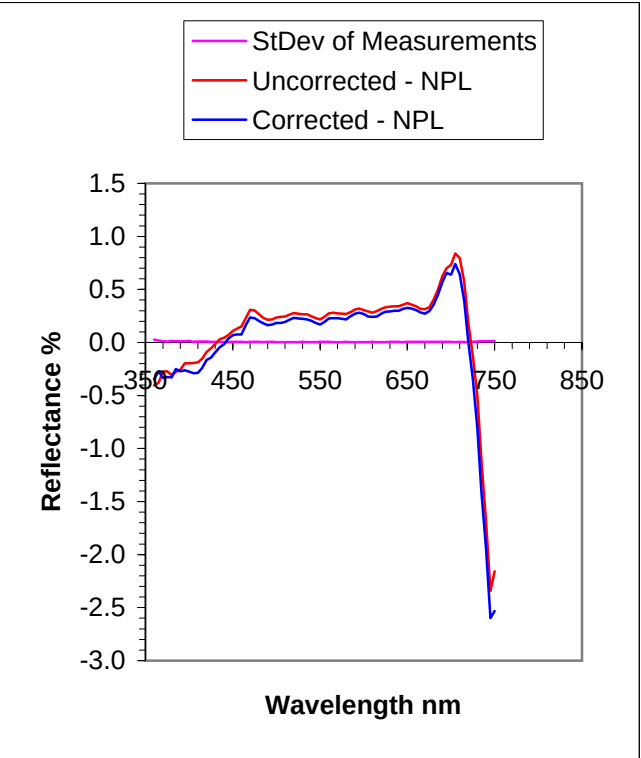
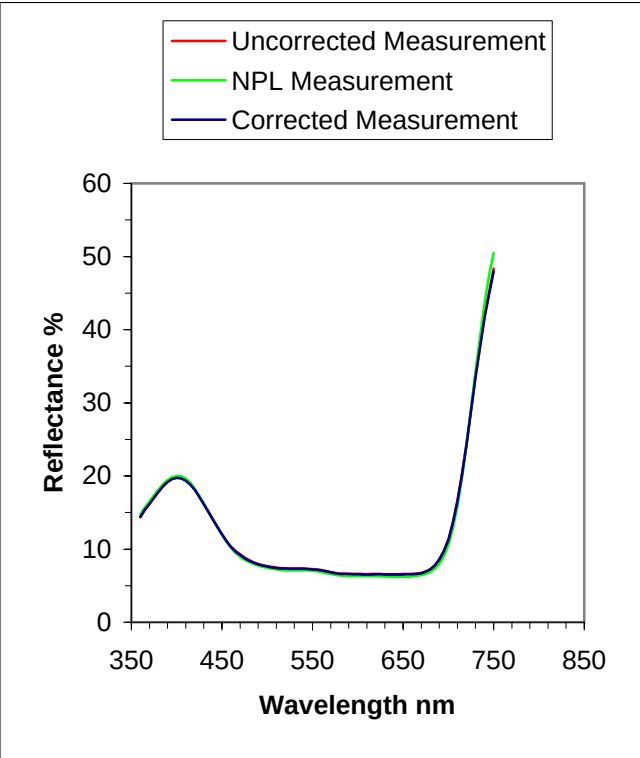
**Black
Matt**



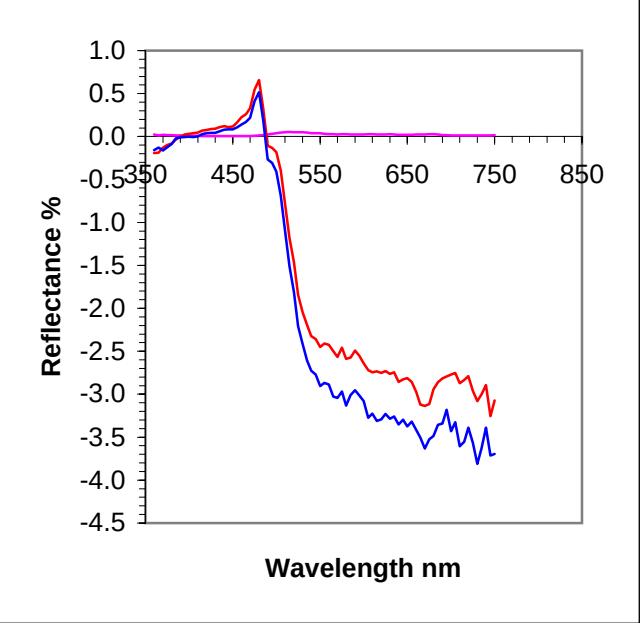
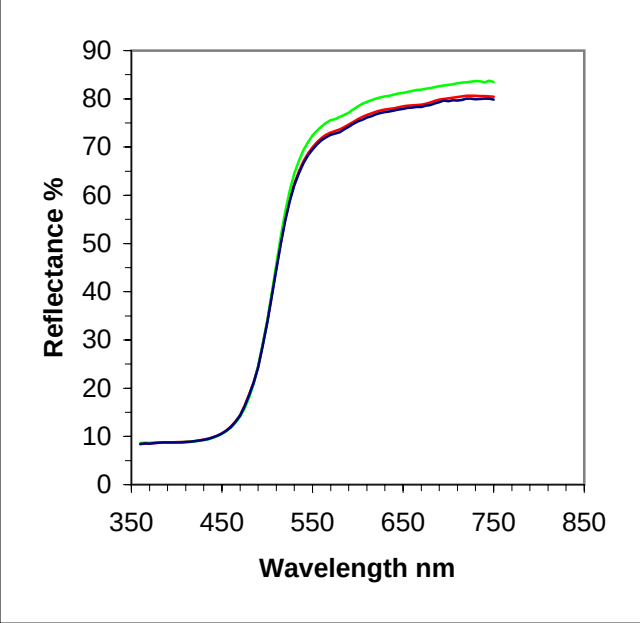
Red
Matt



Cyan
Matt



Blue
Matt



Yellow
Matt

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 25 mm (Large)

Geometry: SPEX

Tiles: Matt

NPL Master Tiles: Colours CCM6

White WT45

Black BT10

Grey GT41

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0125	R%	+	0.1100
450 nm	Uncert =	0.0078	R%	+	0.1101
500 nm	Uncert =	0.0092	R%	+	0.1763
550 nm	Uncert =	0.0075	R%	+	0.2034
600 nm	Uncert =	0.0083	R%	+	0.1951
650 nm	Uncert =	0.0084	R%	+	0.1551
700 nm	Uncert =	0.0091	R%	+	0.1684

<= 460 nm Uncert = **0.012** R% + **0.110** (k = 2)

>= 465 nm Uncert = **0.010** R% + **0.200** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	0.44	0.64
a*	0.09	0.23
b*	0.04	0.30

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0040	R%	+	0.2459
450 nm	Uncert =	0.0047	R%	+	0.1727
500 nm	Uncert =	0.0059	R%	+	0.1224
550 nm	Uncert =	0.0059	R%	+	0.1444
600 nm	Uncert =	0.0057	R%	+	0.1316
650 nm	Uncert =	0.0051	R%	+	0.1250
700 nm	Uncert =	0.0055	R%	+	0.1137

<= 460 nm Uncert = **0.005** R% + **0.250** (k = 2)

>= 460 nm Uncert = **0.006** R% + **0.150** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	0.29	0.46
a*	0.09	0.18
b*	0.12	0.32

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.10	0.85	0.50	0.51	0.31	0.37	0.37	0.60	0.88	0.47	0.47	0.44	0.27	0.27	0.71
x	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004	0.0006	0.0015	0.0008	0.0005	0.0004	0.0004	0.0006	0.0013	0.0008	< 0.0001
y	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0006	0.0005	0.0004	0.0004	0.0004	0.0003	0.0003	0.0005	0.0022	0.0013	< 0.0001
L*	0.46	0.44	0.43	0.43	0.53	0.47	0.47	0.44	0.44	0.44	0.44	0.44	0.63	0.64	0.43
a*	0.02	0.01	0.01	0.01	0.06	0.14	0.23	0.09	0.15	0.12	0.13	0.05	0.19	0.09	< 0.01
b*	0.04	0.02	0.03	0.03	0.14	0.08	0.14	0.17	0.04	0.04	0.04	0.03	0.30	0.23	< 0.01

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

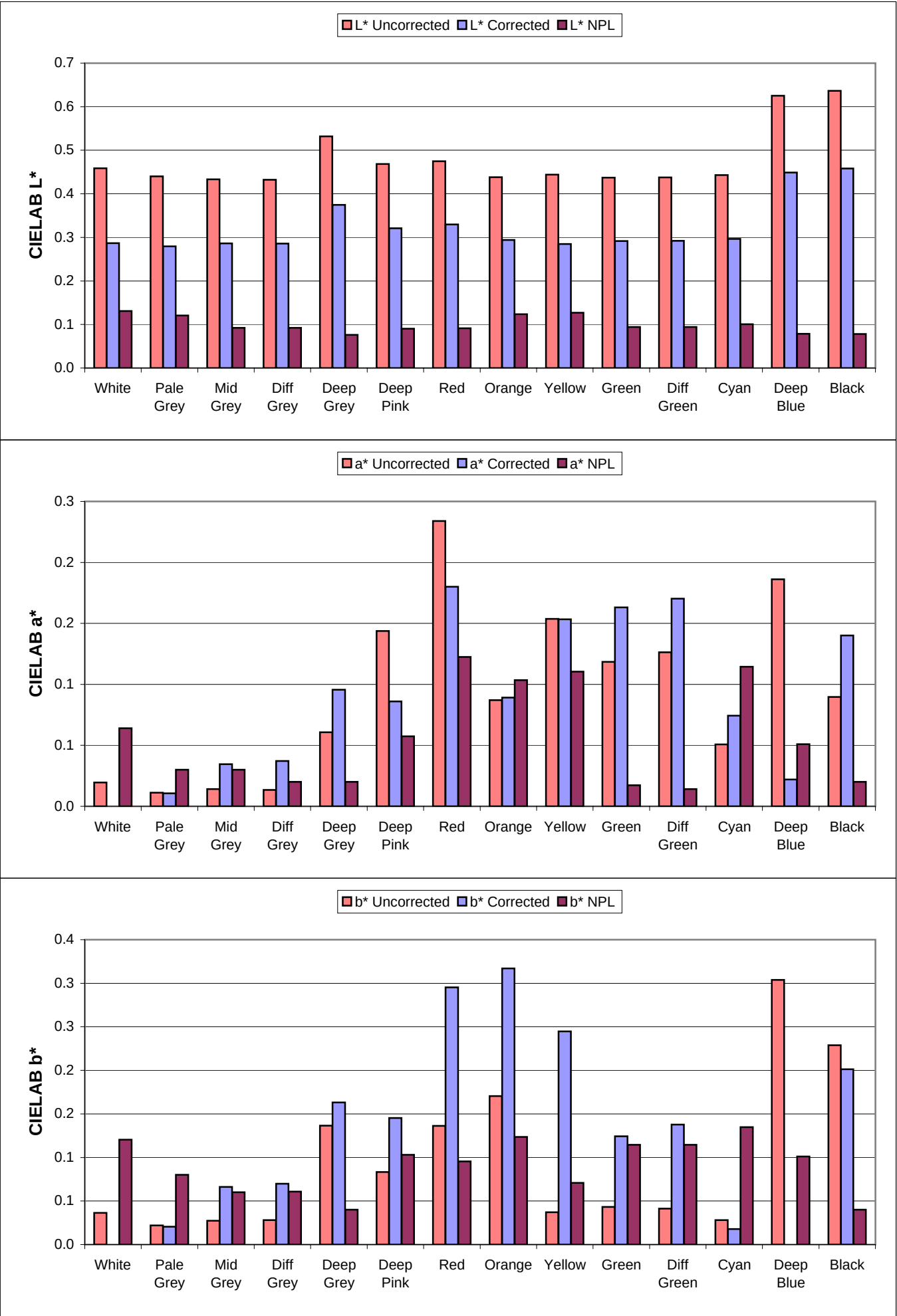
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.69	0.54	0.33	0.34	0.21	0.25	0.26	0.40	0.56	0.31	0.31	0.29	0.19	0.19	0.46
x	< 0.0001	< 0.0001	< 0.0001	0.0001	0.0003	0.0009	0.0018	0.0010	0.0006	0.0003	0.0003	0.0004	0.0005	0.0003	< 0.0001
y	< 0.0001	< 0.0001	0.0002	0.0002	0.0007	0.0003	0.0005	0.0006	0.0007	0.0008	0.0009	0.0002	0.0006	0.0010	< 0.0001
L*	0.29	0.28	0.29	0.29	0.37	0.32	0.33	0.29	0.28	0.29	0.29	0.30	0.45	0.46	0.28
a*	< 0.01	0.01	0.03	0.04	0.10	0.09	0.18	0.09	0.15	0.16	0.17	0.07	0.02	0.14	0.02
b*	< 0.01	0.02	0.07	0.07	0.16	0.15	0.30	0.32	0.24	0.12	0.14	0.02	< 0.01	0.20	0.03

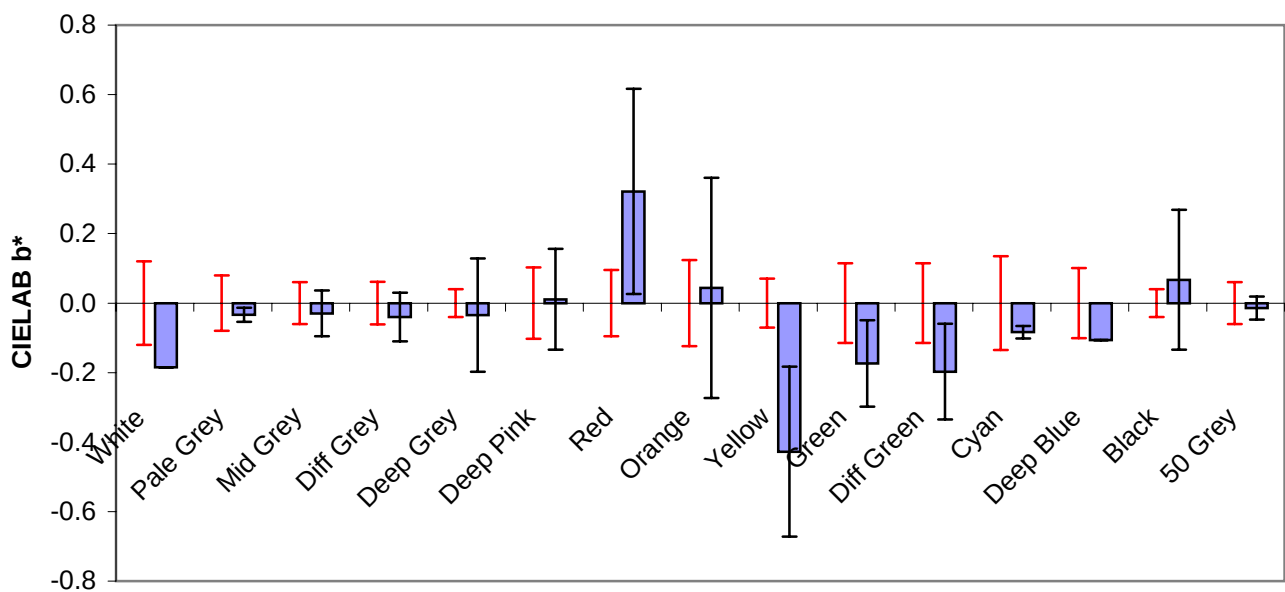
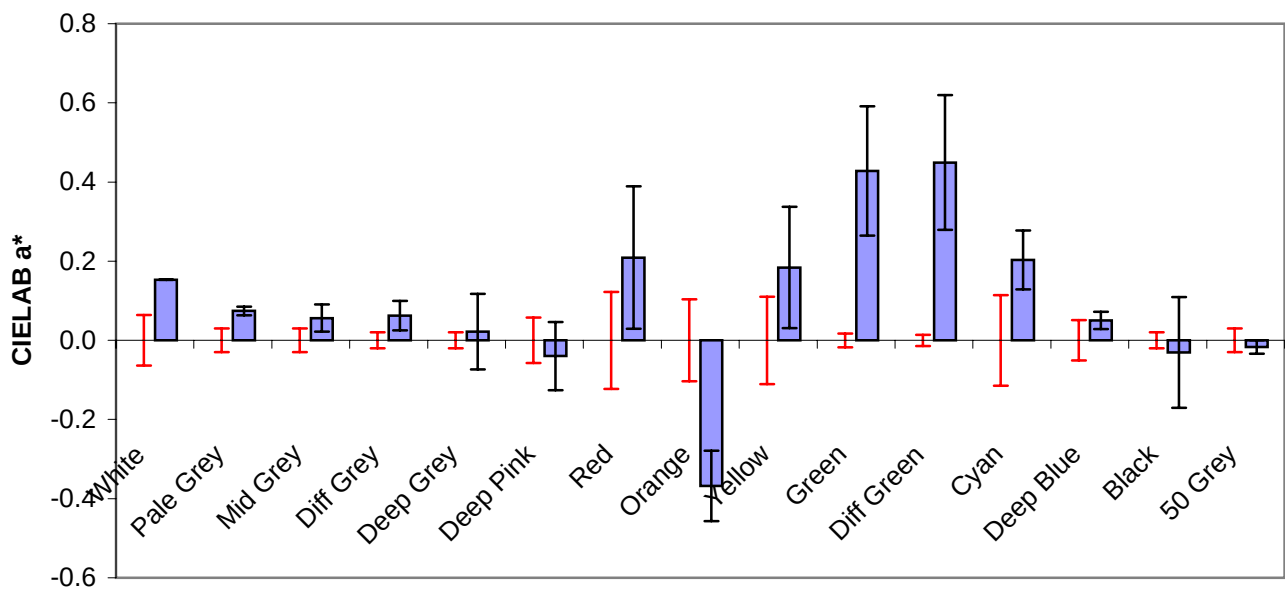
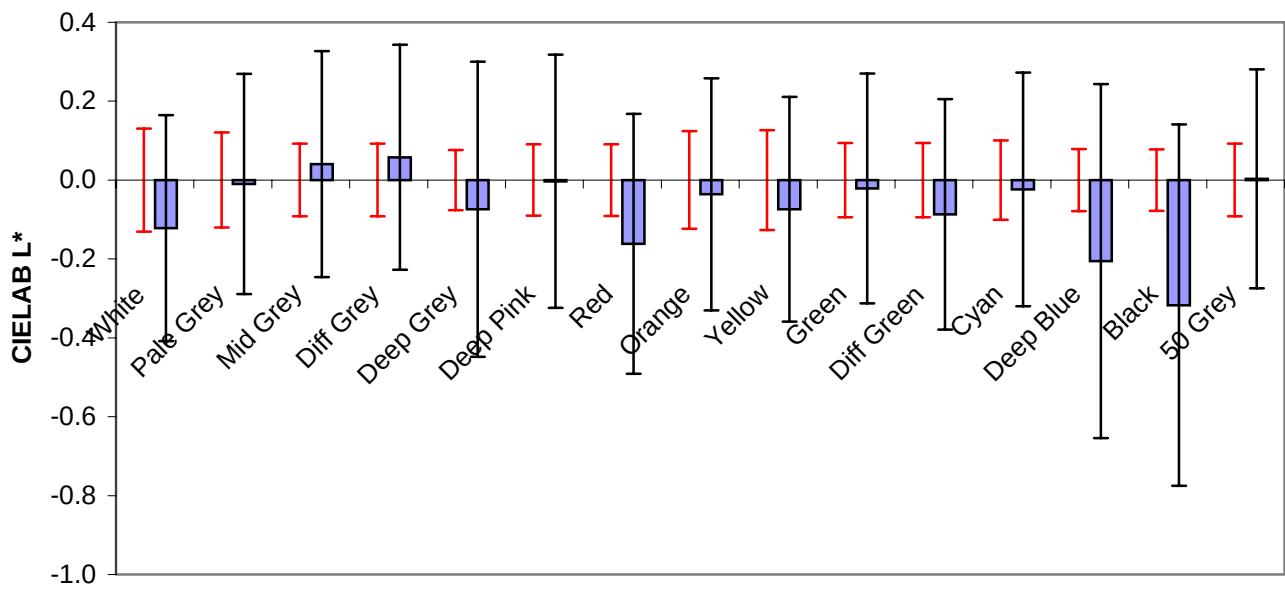
NPL Lambda Uncertainty

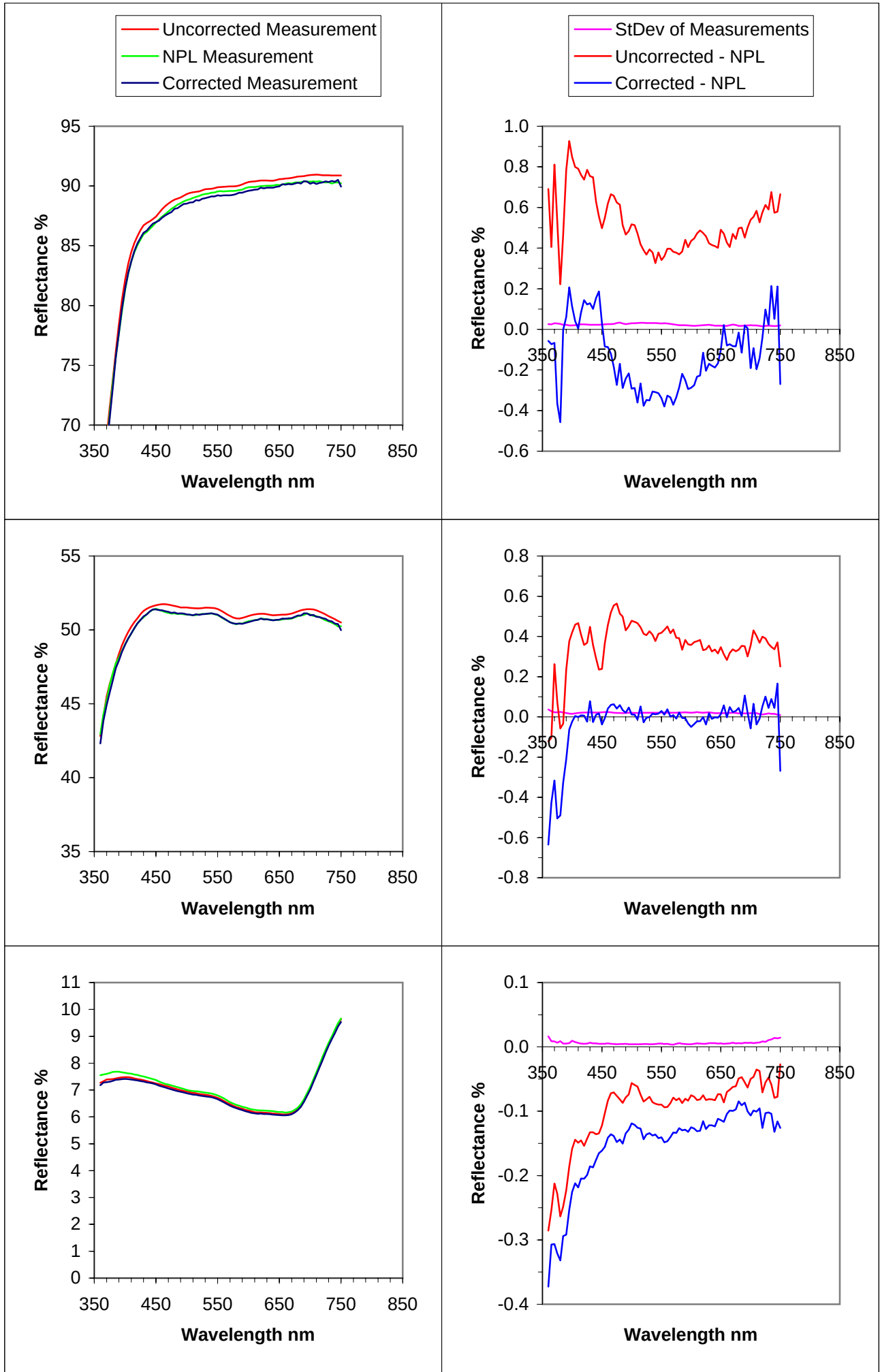
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.32	0.23	0.11	0.11	0.04	0.07	0.07	0.17	0.23	0.10	0.09	0.10	0.04	0.03	0.11
x	0.0002	0.0001	0.0001	0.0001	0.0001	0.0003	0.0005	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001
y	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0001	0.0003	0.0002	0.0005	0.0004	0.0004	0.0004	0.0002	0.0002
L*	0.13	0.12	0.09	0.09	0.08	0.09	0.09	0.12	0.13	0.09	0.09	0.10	0.08	0.08	0.09
a*	0.06	0.03	0.03	0.02	0.02	0.06	0.12	0.10	0.11	0.02	0.01	0.11	0.05	0.02	0.03
b*	0.12	0.08	0.06	0.06	0.04	0.10	0.10	0.12	0.07	0.11	0.11	0.13	0.10	0.04	0.06

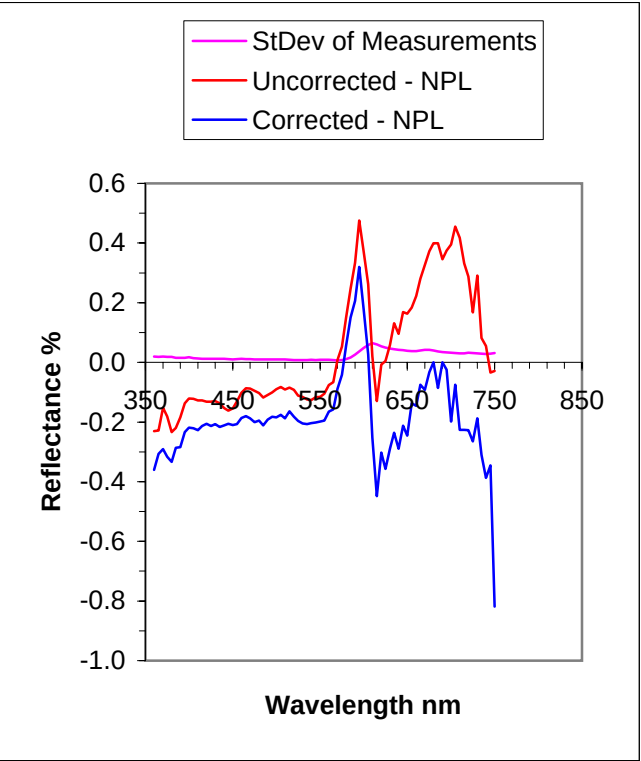
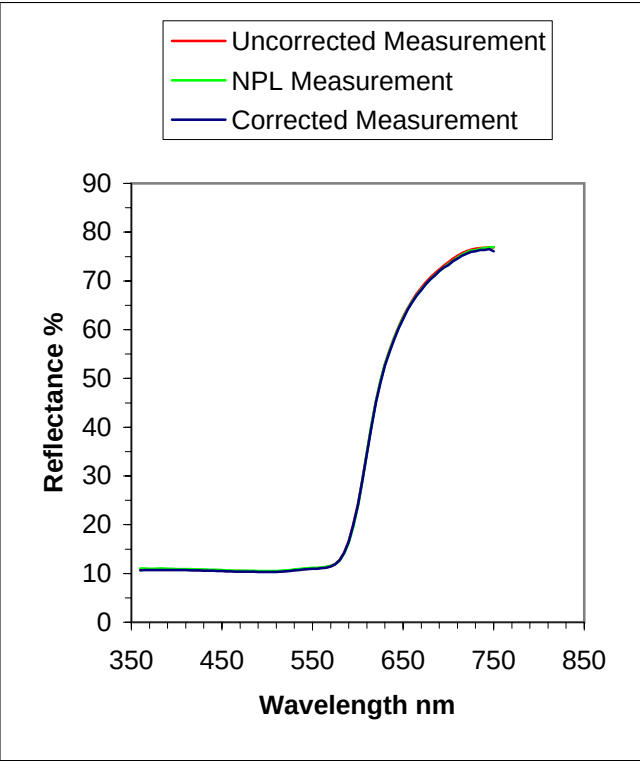
Colorimetry

			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	95.93	84.52	62.07	62.64	38.89	48.43	47.95	69.03	85.56	58.94	58.96	56.26	31.52	30.88	76.81
		a*	-0.32	-0.35	-0.25	-1.98	-0.82	22.70	36.65	35.91	-4.62	-27.32	-27.61	-10.26	6.97	-0.86	-0.28
		b*	1.57	0.27	0.03	1.65	-0.80	3.21	15.70	45.67	70.78	10.35	12.77	-28.18	-16.18	-2.42	-0.30
Average Measurement (Uncorrected)	B	L*	95.93	84.51	62.07	62.63	38.89	48.43	47.90	68.97	85.54	58.93	58.93	56.25	31.53	30.87	76.82
		a*	-0.33	-0.35	-0.25	-1.97	-0.82	22.67	36.56	35.92	-4.53	-27.26	-27.56	-10.23	6.95	-0.86	-0.28
		b*	1.57	0.27	0.03	1.65	-0.80	3.20	15.65	45.53	70.81	10.32	12.77	-28.18	-16.16	-2.42	-0.30
Average Measurement (Corrected)	C	L*	95.64	84.25	61.86	62.43	38.75	48.26	47.74	68.75	85.27	58.73	58.74	56.05	31.40	30.75	76.57
		a*	-0.26	-0.29	-0.21	-1.92	-0.78	22.65	36.51	35.86	-4.48	-27.15	-27.44	-10.14	6.97	-0.83	-0.22
		b*	1.54	0.24	0.01	1.63	-0.81	3.18	15.61	45.41	70.62	10.29	12.72	-28.13	-16.14	-2.43	-0.32
NPL Values	D	L*	95.76	84.26	61.82	62.37	38.82	48.26	47.90	68.78	85.35	58.75	58.82	56.08	31.61	31.07	76.57
		a*	-0.41	-0.36	-0.26	-1.99	-0.81	22.69	36.31	36.23	-4.66	-27.58	-27.89	-10.35	6.92	-0.80	-0.20
		b*	1.73	0.28	0.04	1.67	-0.78	3.16	15.29	45.37	71.05	10.46	12.92	-28.05	-16.03	-2.50	-0.31
A to B		dE*	0.013	0.005	0.006	0.008	0.005	0.034	0.103	0.150	0.094	0.067	0.054	0.038	0.024	0.008	0.007
B to C		dE*	0.303	0.272	0.211	0.214	0.149	0.168	0.174	0.255	0.325	0.232	0.233	0.216	0.128	0.127	0.251
B to D		dE*	0.246	0.254	0.246	0.265	0.075	0.167	0.447	0.398	0.335	0.385	0.385	0.244	0.155	0.217	0.258
C to D		dE*	0.269	0.082	0.075	0.094	0.084	0.041	0.416	0.372	0.471	0.462	0.498	0.221	0.237	0.326	0.022
Corrected + Uncertainty	E	L*	95.93	84.53	62.15	62.71	39.12	48.58	48.07	69.04	85.56	59.02	59.03	56.35	31.85	31.21	76.85
		a*	-0.26	-0.28	-0.17	-1.89	-0.69	22.74	36.69	35.95	-4.33	-26.98	-27.27	-10.07	6.99	-0.69	-0.20
		b*	1.55	0.26	0.08	1.70	-0.65	3.32	15.91	45.73	70.87	10.41	12.86	-28.11	-16.13	-2.23	-0.29
Corrected - Uncertainty	F	L*	95.35	83.97	61.58	62.14	38.38	47.94	47.41	68.45	84.99	58.44	58.44	55.76	30.95	30.29	76.30
		a*	-0.26	-0.30	-0.24	-1.96	-0.88	22.56	36.33	35.77	-4.63	-27.31	-27.61	-10.22	6.95	-0.97	-0.24
		b*	1.54	0.22	-0.05	1.56	-0.98	3.03	15.32	45.09	70.38	10.16	12.59	-28.15	-16.14	-2.63	-0.36

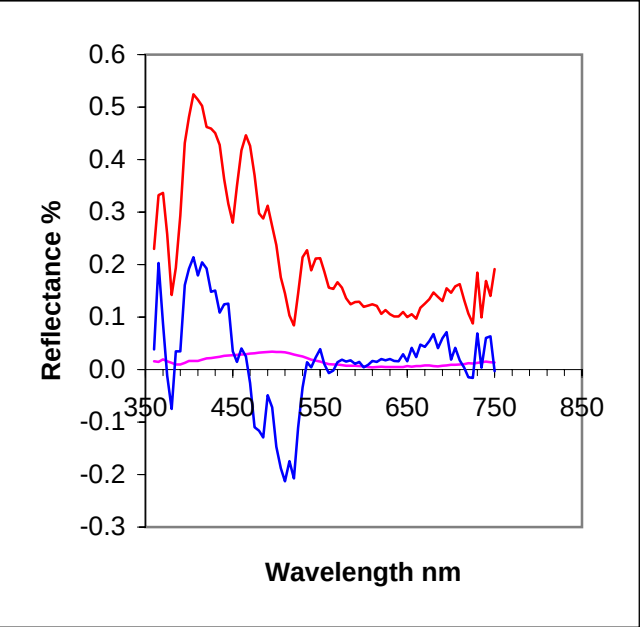
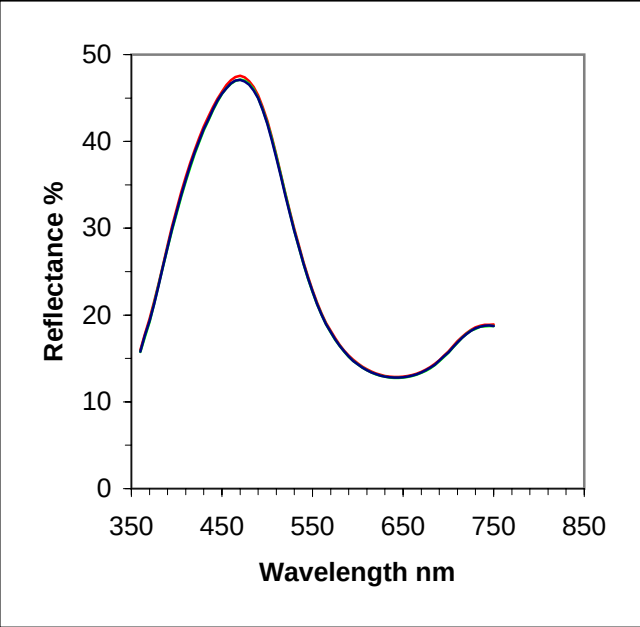




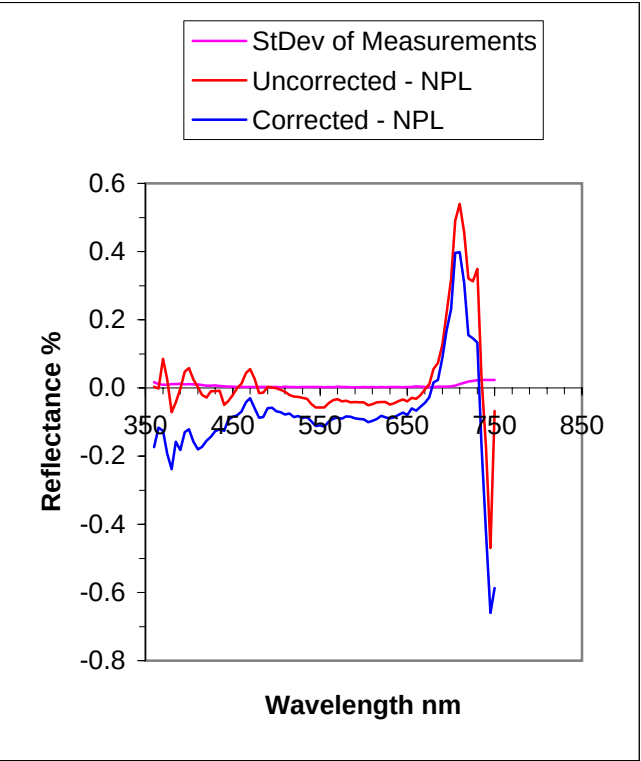
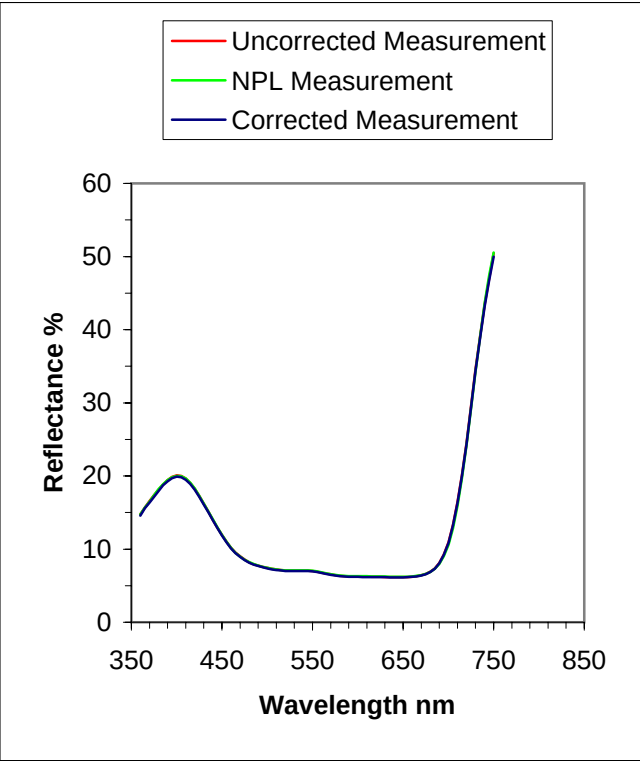




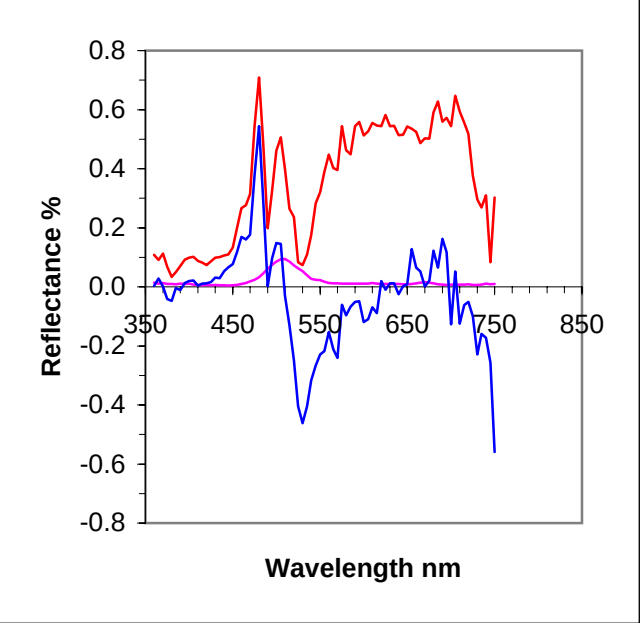
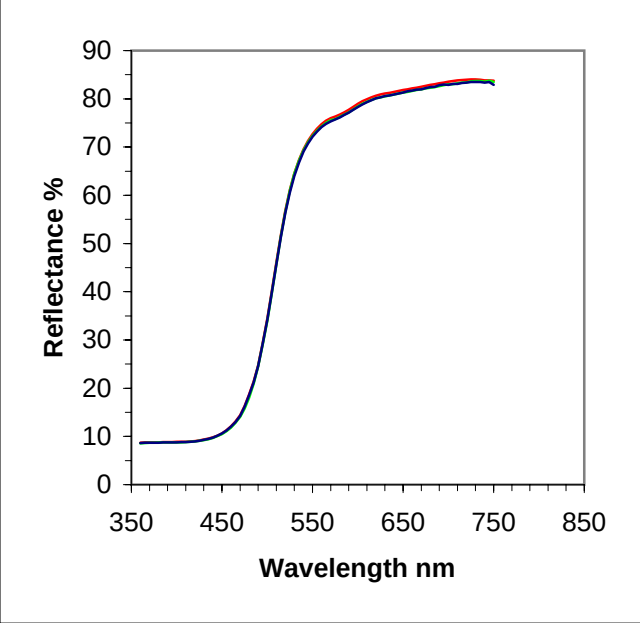
Red
Matt



Cyan
Matt



**Blue
Matt**



**Yellow
Matt**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 10 mm (Medium)

Geometry: SPEX

Tiles: Matt

NPL Master Tiles: Colours CCM6

White WT45

Black BT10

Grey GT41

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0662	R%	+	0.2862
450 nm	Uncert =	0.0587	R%	+	0.3642
500 nm	Uncert =	0.0573	R%	+	0.3064
550 nm	Uncert =	0.0542	R%	+	0.3017
600 nm	Uncert =	0.0551	R%	+	0.3631
650 nm	Uncert =	0.0564	R%	+	0.3254
700 nm	Uncert =	0.0584	R%	+	0.2969

<= 460 nm Uncert = **0.070** R% + **0.400** (k = 2)

>= 465 nm Uncert = **0.060** R% + **0.400** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	1.96	2.49
a*	0.18	0.58
b*	0.26	0.68

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0543	R%	+	0.3604
450 nm	Uncert =	0.0519	R%	+	0.3916
500 nm	Uncert =	0.0462	R%	+	0.3235
550 nm	Uncert =	0.0449	R%	+	0.3194
600 nm	Uncert =	0.0454	R%	+	0.3745
650 nm	Uncert =	0.0485	R%	+	0.3476
700 nm	Uncert =	0.0487	R%	+	0.2954

<= 460 nm Uncert = **0.06** R% + **0.400** (k = 2)

>= 460 nm Uncert = **0.05** R% + **0.400** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	1.69	2.09
a*	0.16	0.45
b*	0.28	0.58

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	6.05	4.43	2.32	2.35	1.07	1.48	1.45	2.86	4.60	2.08	2.08	1.91	0.84	0.81	3.58
x	0.0005	0.0005	0.0005	0.0005	0.0003	0.0021	0.0040	0.0024	0.0012	0.0004	0.0003	0.0009	0.0016	0.0003	0.0005
y	0.0010	0.0010	0.0010	0.0010	0.0009	0.0005	0.0005	0.0011	0.0015	0.0019	0.0021	0.0001	0.0024	0.0005	0.0009
L*	2.49	2.29	1.97	1.97	1.85	1.85	1.85	2.05	2.31	1.93	1.93	1.91	1.94	1.96	2.17
a*	0.21	0.20	0.16	0.13	0.12	0.27	0.38	0.58	0.16	0.17	0.18	0.20	0.07	0.13	0.18
b*	0.40	0.39	0.31	0.28	0.22	0.26	0.26	0.26	0.67	0.14	0.11	0.68	0.09	0.15	0.37

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

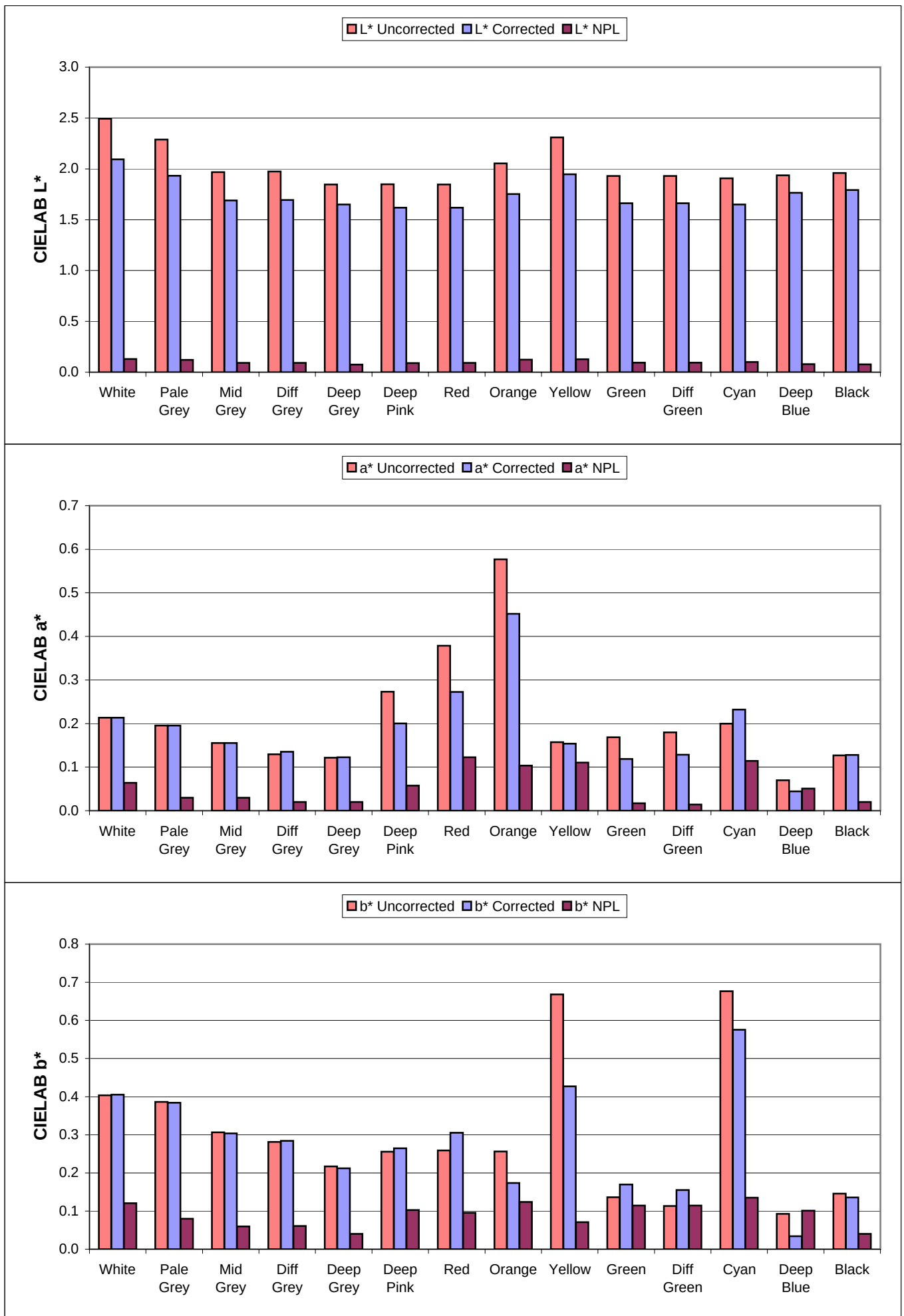
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	5.07	3.74	1.99	2.01	0.95	1.29	1.27	2.43	3.88	1.79	1.79	1.65	0.76	0.74	3.03
x	0.0005	0.0005	0.0005	0.0004	0.0003	0.0021	0.0040	0.0024	0.0012	0.0004	0.0003	0.0009	0.0016	0.0003	0.0004
y	0.0009	0.0009	0.0009	0.0010	0.0009	0.0005	0.0005	0.0011	0.0015	0.0019	0.0021	0.0001	0.0024	0.0004	0.0009
L*	2.09	1.93	1.69	1.69	1.65	1.62	1.62	1.75	1.95	1.66	1.66	1.65	1.77	1.79	1.84
a*	0.21	0.20	0.16	0.14	0.12	0.20	0.27	0.45	0.15	0.12	0.13	0.23	0.04	0.13	0.18
b*	0.41	0.38	0.30	0.28	0.21	0.26	0.31	0.17	0.43	0.17	0.16	0.58	0.03	0.14	0.36

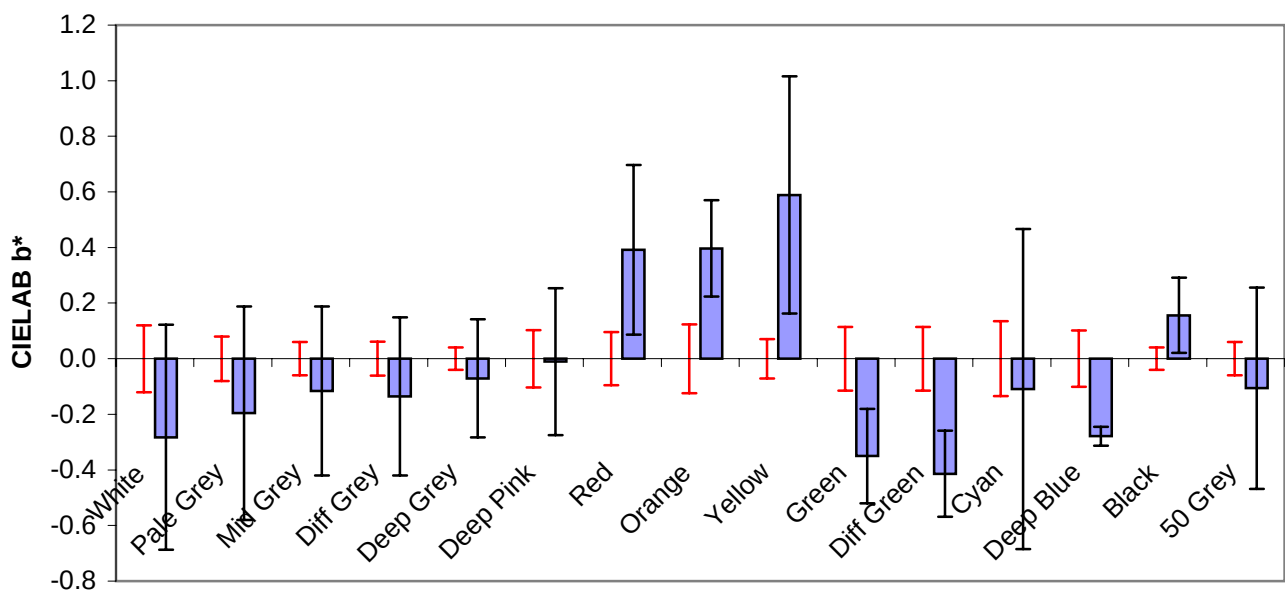
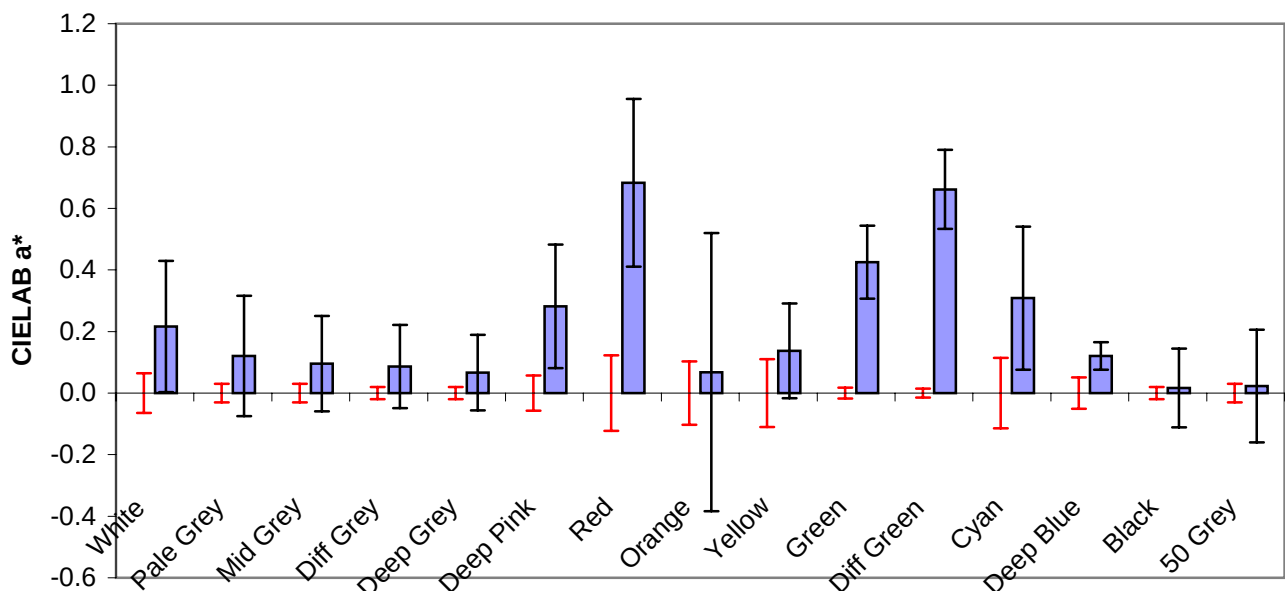
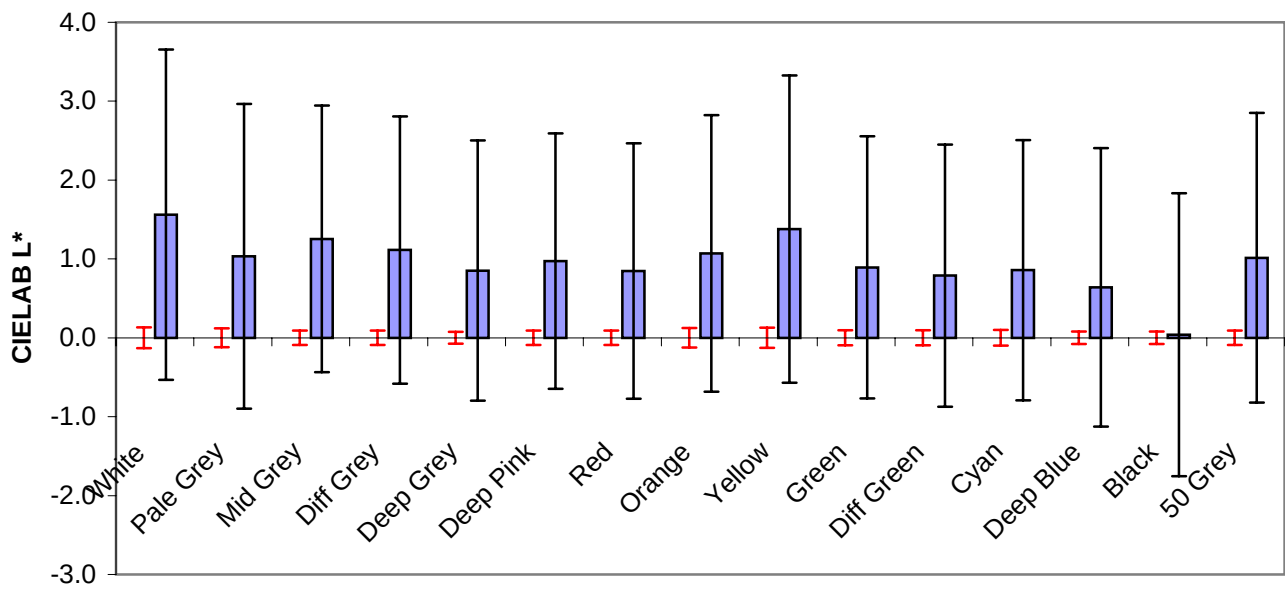
NPL Lambda Uncertainty

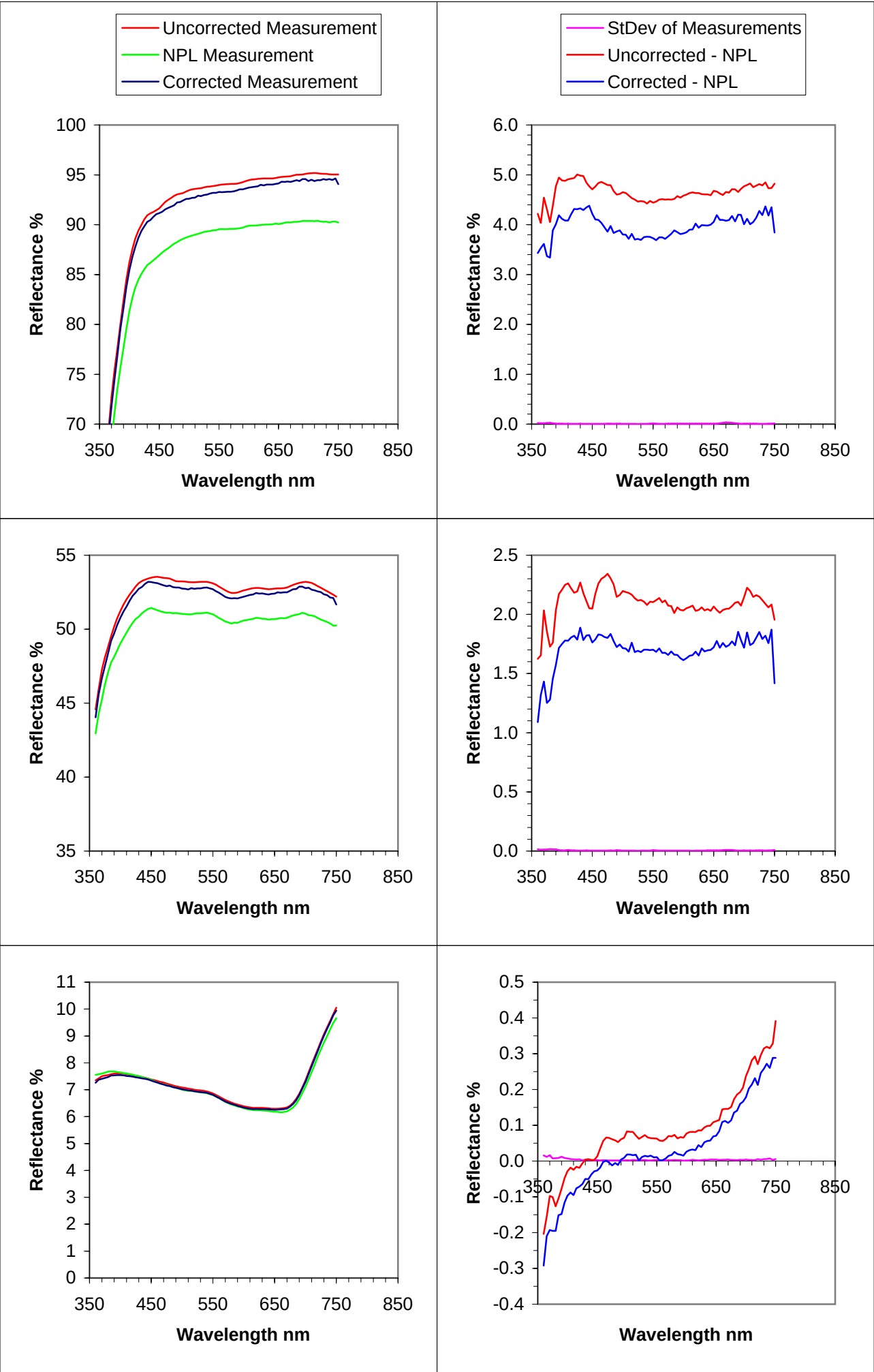
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.32	0.23	0.11	0.11	0.04	0.07	0.07	0.17	0.23	0.10	0.09	0.10	0.04	0.03	0.11
x	0.0002	0.0001	0.0001	0.0001	0.0001	0.0003	0.0005	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001
y	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0001	0.0003	0.0002	0.0005	0.0004	0.0004	0.0004	0.0002	0.0002
L*	0.13	0.12	0.09	0.09	0.08	0.09	0.09	0.12	0.13	0.09	0.09	0.10	0.08	0.08	0.09
a*	0.06	0.03	0.03	0.02	0.02	0.06	0.12	0.10	0.11	0.02	0.01	0.11	0.05	0.02	0.03
b*	0.12	0.08	0.06	0.06	0.04	0.10	0.10	0.12	0.07	0.11	0.11	0.13	0.10	0.04	0.06

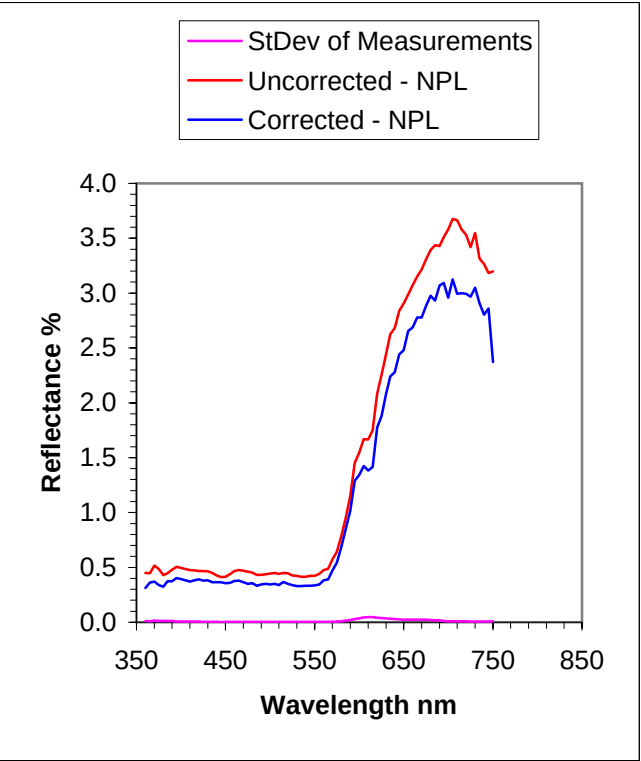
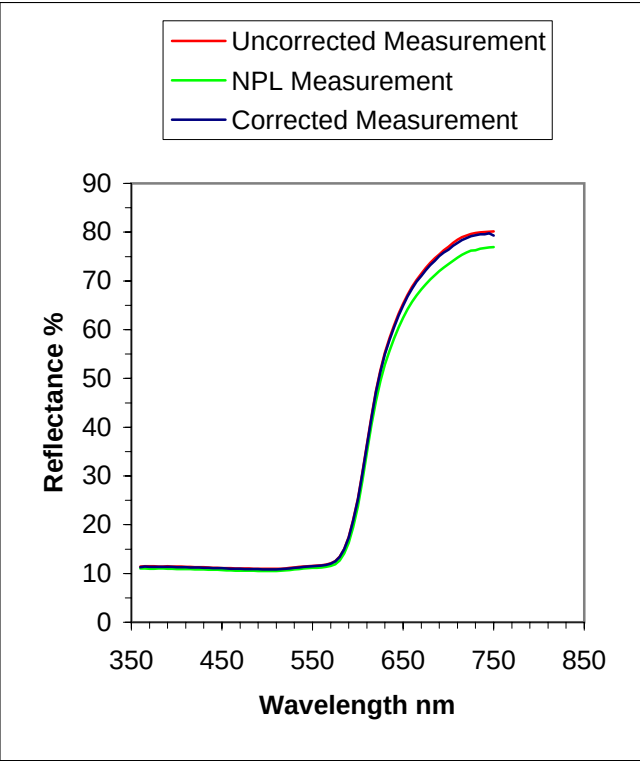
Colorimetry

			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	97.62	85.56	63.29	63.69	39.82	49.41	48.93	70.11	87.03	59.86	59.82	57.14	32.38	31.23	77.84
		a*	-0.26	-0.30	-0.21	-1.95	-0.78	23.01	37.08	36.34	-4.62	-27.30	-27.39	-10.14	7.03	-0.81	-0.24
		b*	1.48	0.11	-0.05	1.56	-0.84	3.18	15.76	45.95	71.86	10.15	12.55	-28.20	-16.33	-2.34	-0.39
Average Measurement (Uncorrected)	B	L*	97.62	85.56	63.28	63.69	39.82	49.41	48.91	70.07	86.99	59.85	59.81	57.13	32.37	31.23	77.83
		a*	-0.27	-0.30	-0.22	-1.95	-0.78	22.99	37.04	36.36	-4.58	-27.27	-27.35	-10.12	7.02	-0.81	-0.24
		b*	1.47	0.11	-0.05	1.56	-0.84	3.18	15.72	45.89	71.83	10.15	12.55	-28.21	-16.33	-2.34	-0.39
Average Measurement (Corrected)	C	L*	97.32	85.29	63.08	63.48	39.68	49.24	48.75	69.85	86.73	59.65	59.61	56.94	32.25	31.11	77.59
		a*	-0.20	-0.24	-0.17	-1.90	-0.74	22.97	36.99	36.30	-4.53	-27.15	-27.23	-10.04	7.04	-0.78	-0.18
		b*	1.45	0.08	-0.07	1.53	-0.85	3.15	15.68	45.76	71.64	10.11	12.51	-28.16	-16.31	-2.34	-0.41
NPL Values	D	L*	95.76	84.26	61.82	62.37	38.82	48.26	47.90	68.78	85.35	58.75	58.82	56.08	31.61	31.07	76.57
		a*	-0.41	-0.36	-0.26	-1.99	-0.81	22.69	36.31	36.23	-4.66	-27.58	-27.89	-10.35	6.92	-0.80	-0.20
		b*	1.73	0.28	0.04	1.67	-0.78	3.16	15.29	45.37	71.05	10.46	12.92	-28.05	-16.03	-2.50	-0.31
A to B		dE*	0.008	0.003	0.004	0.005	0.001	0.024	0.057	0.070	0.070	0.038	0.041	0.020	0.004	0.005	0.005
B to C		dE*	0.307	0.274	0.214	0.217	0.151	0.170	0.177	0.258	0.330	0.234	0.235	0.218	0.130	0.128	0.253
B to D		dE*	1.881	1.311	1.465	1.327	1.000	1.180	1.323	1.397	1.820	1.179	1.190	1.089	0.831	0.230	1.264
C to D		dE*	1.601	1.057	1.263	1.125	0.857	1.014	1.156	1.143	1.505	1.049	1.110	0.919	0.710	0.162	1.021
Corrected + Uncertainty	E	L*	99.42	87.22	64.77	65.17	41.33	50.86	50.37	71.61	88.67	61.31	61.27	58.59	34.01	32.90	79.42
		a*	0.02	-0.04	-0.01	-1.76	-0.62	23.17	37.26	36.75	-4.37	-27.03	-27.10	-9.80	7.09	-0.65	0.00
		b*	1.85	0.47	0.23	1.82	-0.64	3.42	15.99	45.94	72.07	10.28	12.66	-27.58	-16.28	-2.21	-0.05
Corrected - Uncertainty	F	L*	95.23	83.36	61.39	61.79	38.03	47.62	47.13	68.10	84.78	57.98	57.95	55.29	30.48	29.32	75.75
		a*	-0.41	-0.44	-0.32	-2.03	-0.86	22.77	36.72	35.85	-4.68	-27.27	-27.36	-10.27	7.00	-0.91	-0.36
		b*	1.04	-0.30	-0.38	1.25	-1.06	2.89	15.38	45.59	71.21	9.94	12.35	-28.73	-16.34	-2.48	-0.78

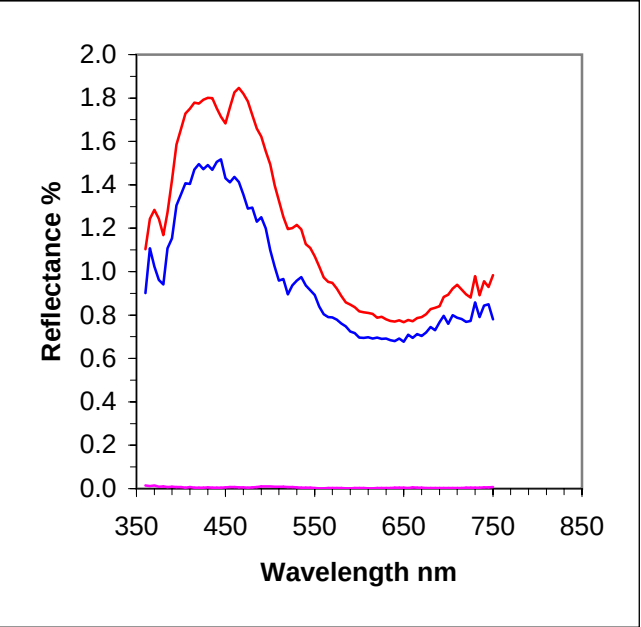
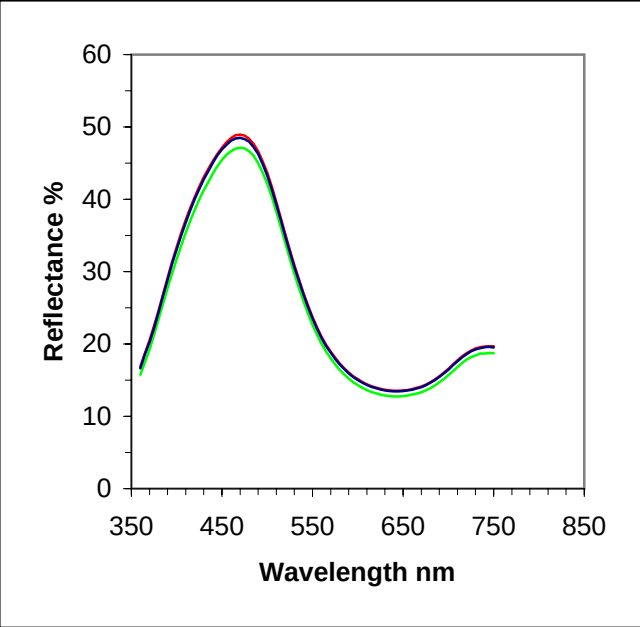




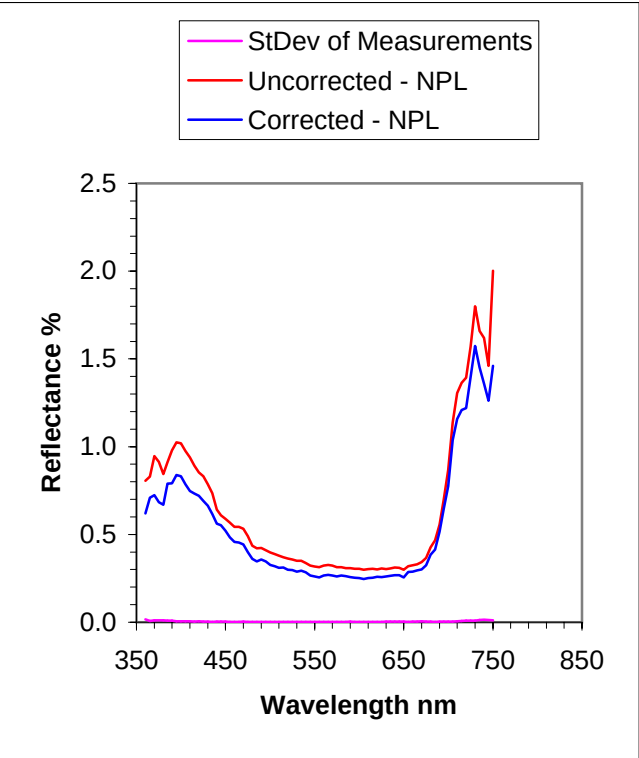
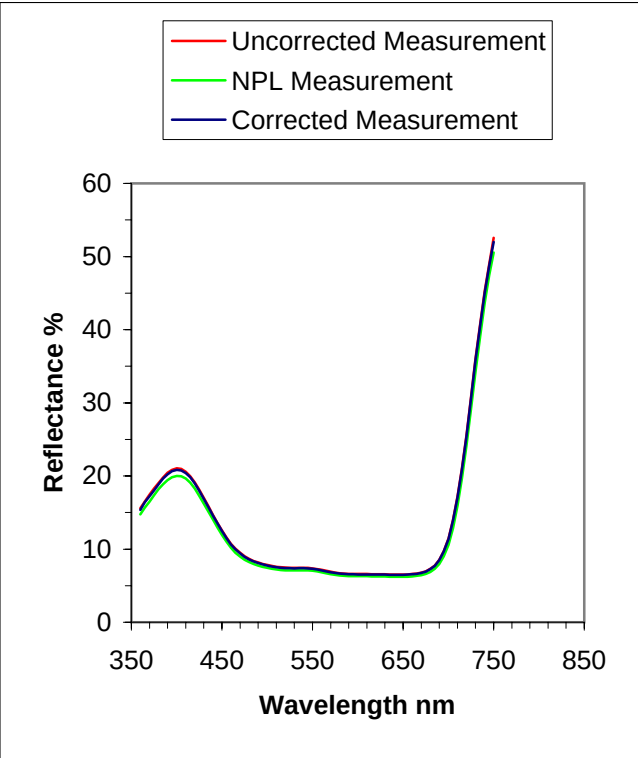




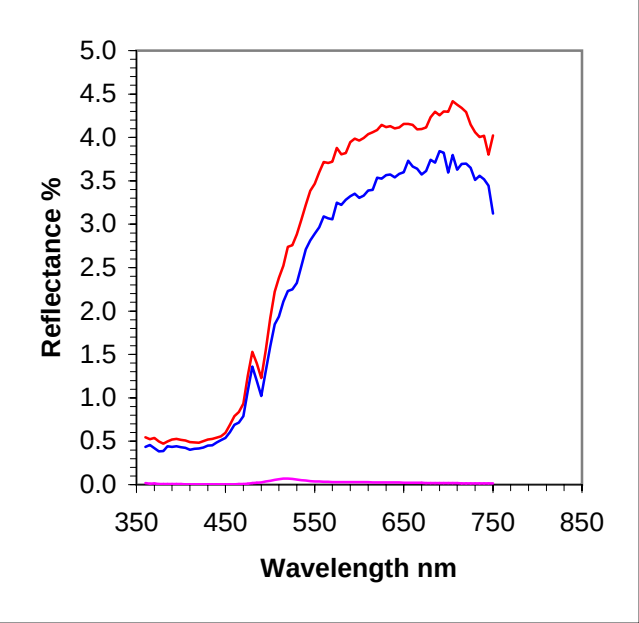
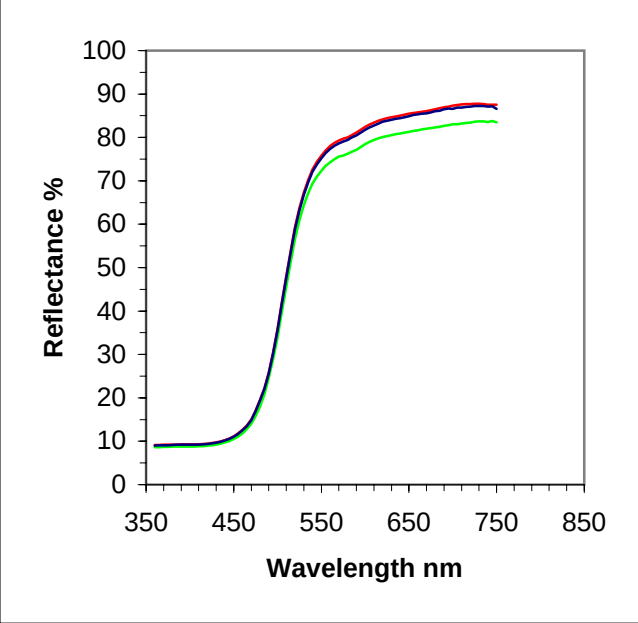
**Red
Matt**



**Cyan
Matt**



Blue
Matt



Yellow
Matt

INSTRUMENT CHARACTERISATION

Instrument: Instrument 1

Aperture: 3 mm (Small)

Geometry: SPEX

Tiles: Matt

NPL Master Tiles: Colours CCM6

White WT45

Black BT10

Grey GT41

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0647	R%	+	0.6215
450 nm	Uncert =	0.0578	R%	+	0.6866
500 nm	Uncert =	0.0565	R%	+	0.9701
550 nm	Uncert =	0.0539	R%	+	1.0638
600 nm	Uncert =	0.0556	R%	+	0.9725
650 nm	Uncert =	0.0572	R%	+	0.9667
700 nm	Uncert =	0.0595	R%	+	0.9758

<= 460 nm Uncert = **0.070** R% + **0.800** (k = 2)

>= 465 nm Uncert = **0.070** R% + **1.100** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	2.99	3.92
a*	0.15	1.00
b*	0.29	1.60

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0538	R%	+	0.6166
450 nm	Uncert =	0.0514	R%	+	0.6827
500 nm	Uncert =	0.0456	R%	+	0.9603
550 nm	Uncert =	0.0448	R%	+	1.0547
600 nm	Uncert =	0.0459	R%	+	0.9638
650 nm	Uncert =	0.0493	R%	+	0.9598
700 nm	Uncert =	0.0498	R%	+	0.9673

<= 460 nm Uncert = **0.06** R% + **0.800** (k = 2)

>= 460 nm Uncert = **0.05** R% + **1.100** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	2.33	3.57
a*	0.17	0.88
b*	0.21	1.43

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	7.69	5.79	3.35	3.41	1.90	2.37	2.33	3.87	5.83	3.06	3.03	2.86	1.62	1.59	4.88
x	0.0001	0.0002	0.0005	0.0004	0.0018	0.0030	0.0079	0.0050	0.0024	0.0020	0.0018	0.0036	0.0072	0.0045	0.0003
y	0.0003	0.0004	0.0009	0.0007	0.0029	0.0026	0.0019	0.0009	0.0025	0.0014	0.0018	0.0033	0.0126	0.0063	0.0005
L*	3.18	3.01	2.86	2.86	3.30	2.99	3.00	2.87	3.01	2.87	2.87	2.88	3.82	3.92	2.93
a*	0.08	0.09	0.15	0.15	0.28	0.55	0.71	0.19	0.21	0.12	0.13	0.11	1.00	0.38	0.11
b*	0.17	0.18	0.29	0.29	0.63	0.39	0.18	0.23	0.47	0.30	0.28	0.22	1.60	1.06	0.20

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

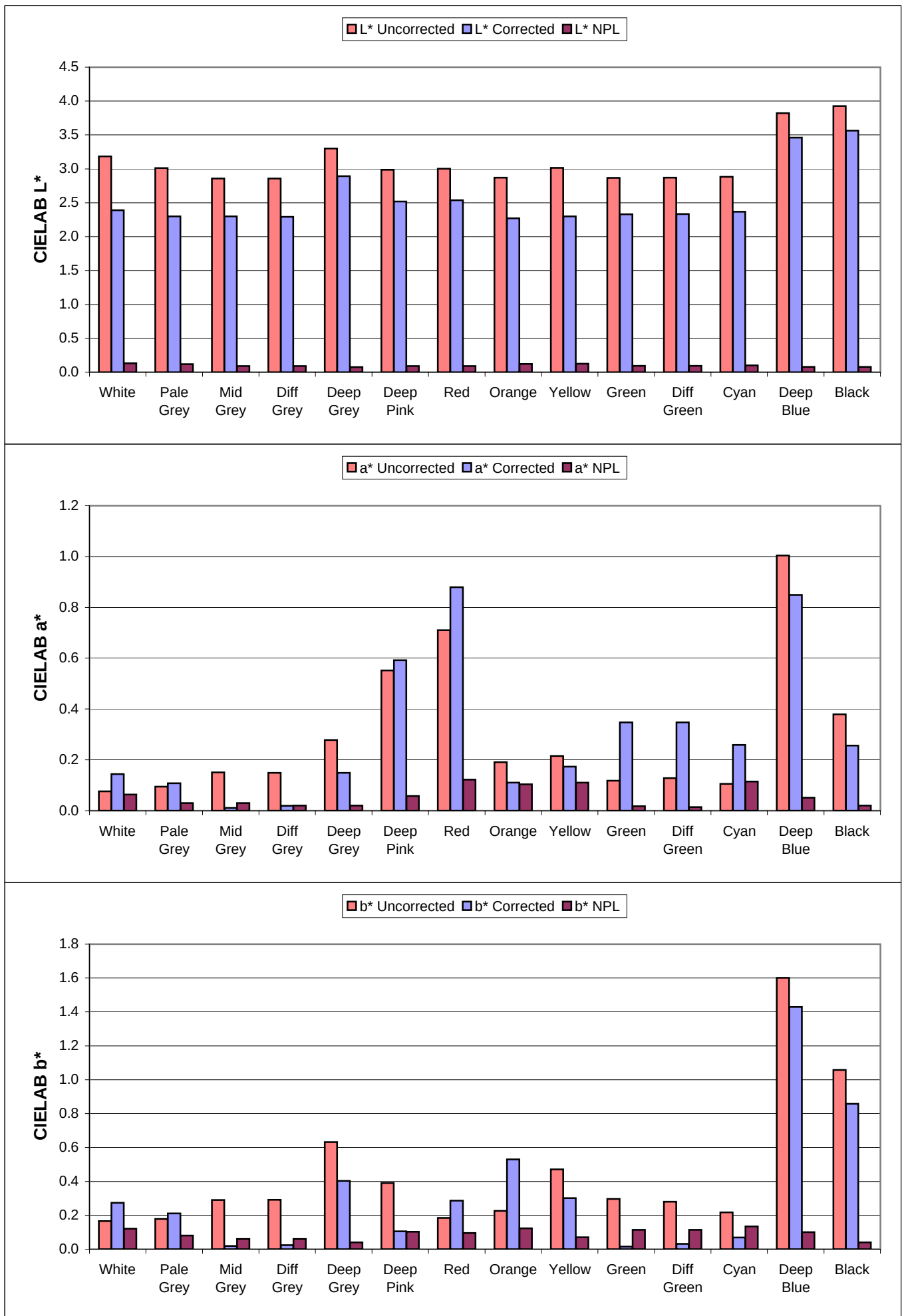
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	5.78	4.43	2.70	2.74	1.67	2.00	1.97	3.06	4.45	2.49	2.47	2.35	1.47	1.44	3.79
x	0.0003	0.0003	< 0.0001	< 0.0001	0.0013	0.0036	0.0084	0.0053	0.0025	0.0017	0.0015	0.0032	0.0066	0.0039	0.0002
y	0.0007	0.0005	< 0.0001	0.0003	0.0019	0.0017	0.0013	0.0014	0.0028	0.0023	0.0027	0.0022	0.0112	0.0051	0.0004
L*	2.39	2.30	2.30	2.29	2.89	2.52	2.54	2.27	2.30	2.33	2.33	2.37	3.46	3.57	2.27
a*	0.14	0.11	0.01	0.02	0.15	0.59	0.88	0.11	0.17	0.35	0.35	0.26	0.85	0.26	0.08
b*	0.27	0.21	0.02	0.02	0.40	0.11	0.29	0.53	0.30	0.01	0.03	0.07	1.43	0.86	0.16

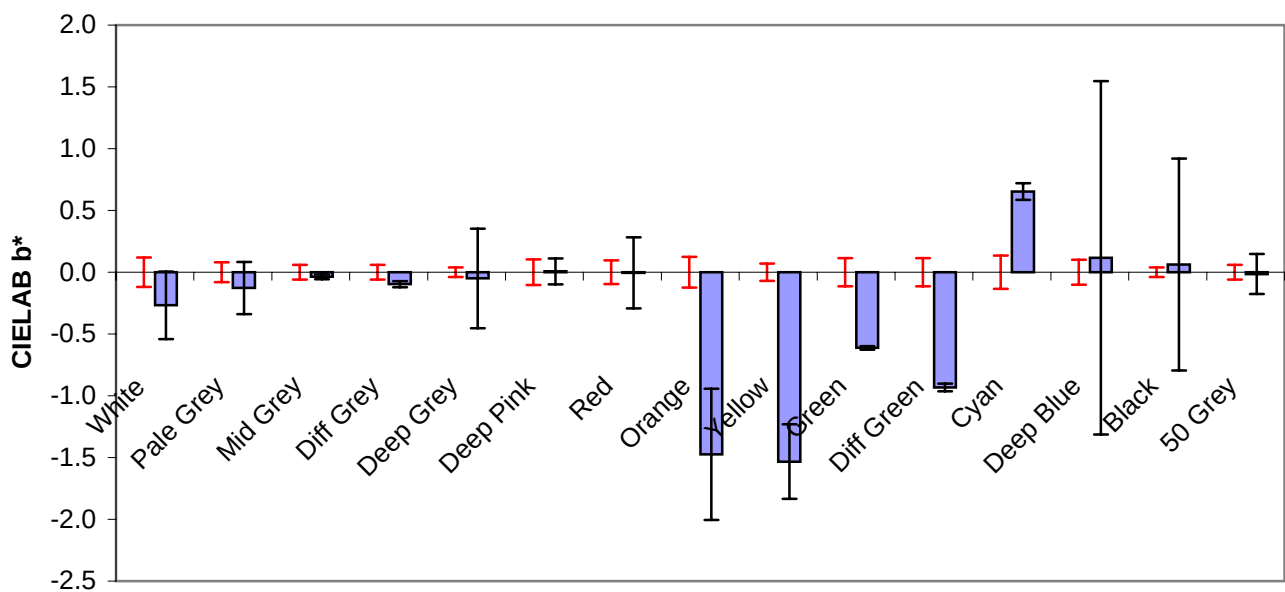
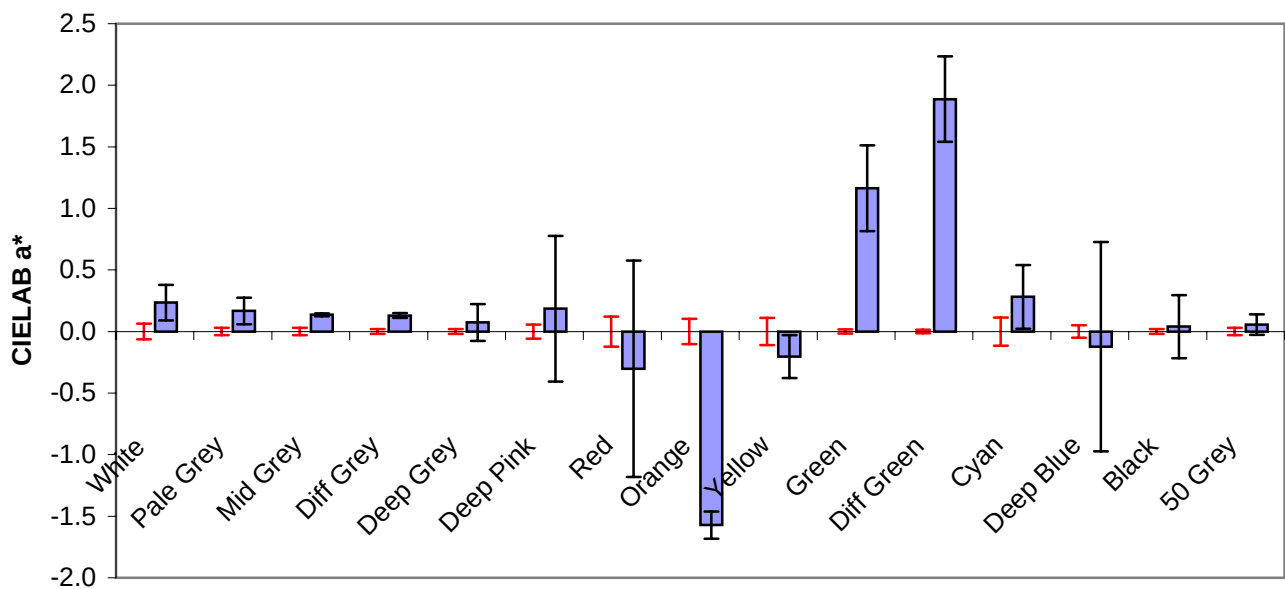
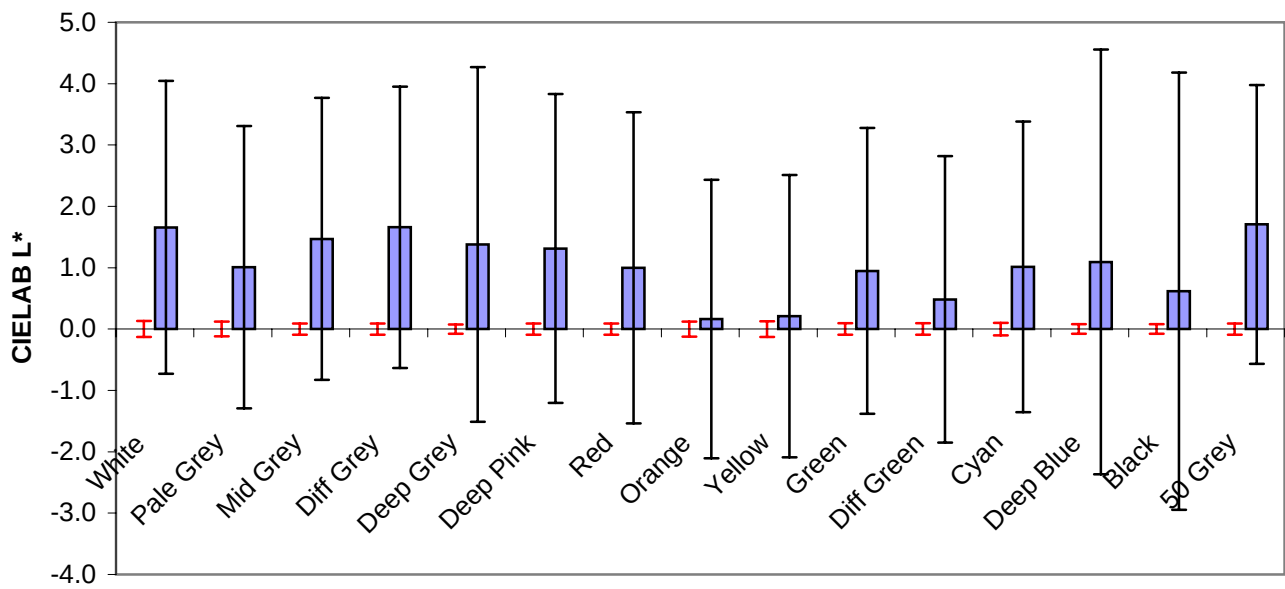
NPL Lambda Uncertainty

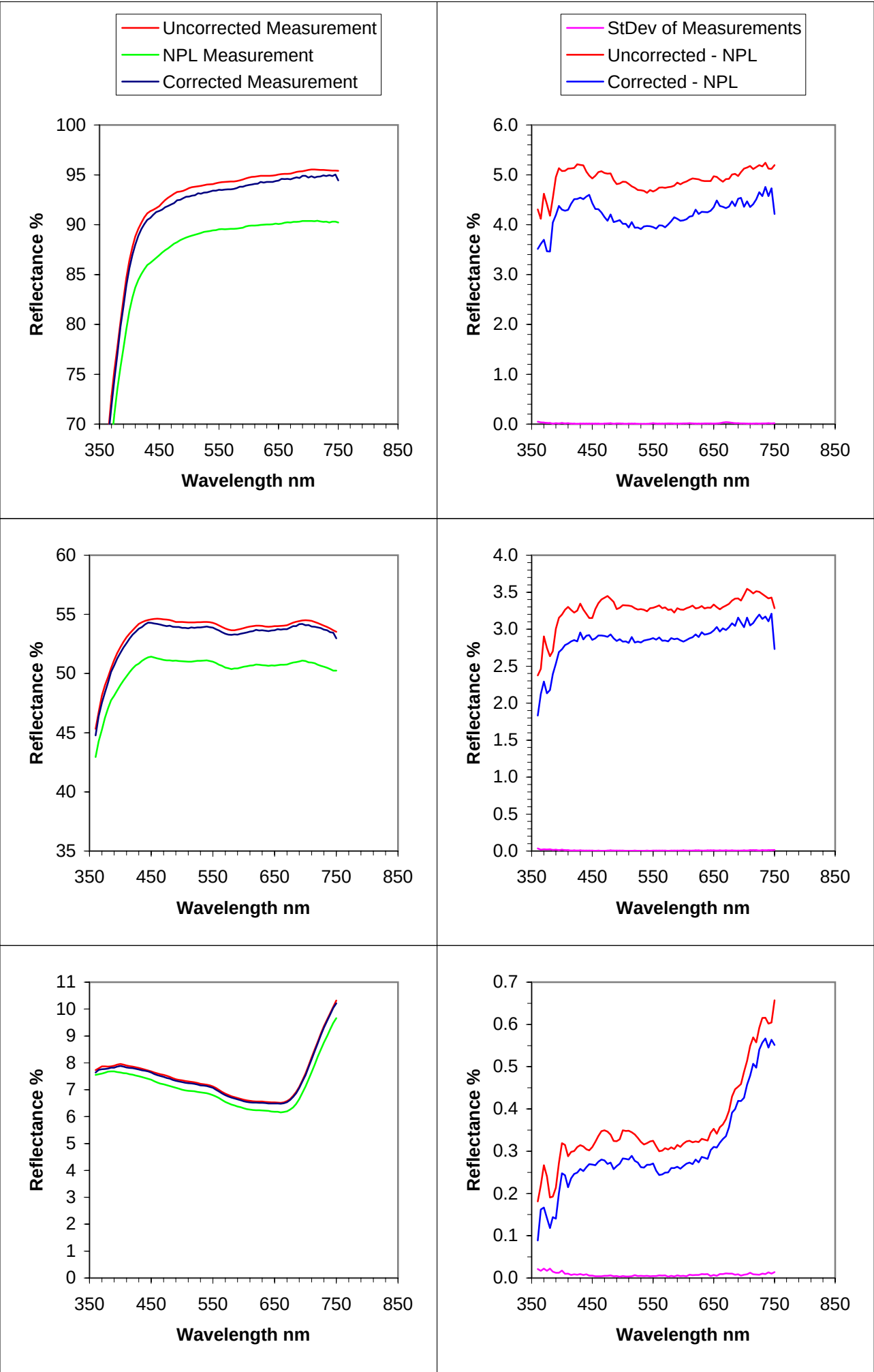
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.32	0.23	0.11	0.11	0.04	0.07	0.07	0.17	0.23	0.10	0.09	0.10	0.04	0.03	0.11
x	0.0002	0.0001	0.0001	0.0001	0.0001	0.0003	0.0005	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001
y	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0001	0.0003	0.0002	0.0005	0.0004	0.0004	0.0004	0.0002	0.0002
L*	0.13	0.12	0.09	0.09	0.08	0.09	0.09	0.12	0.13	0.09	0.09	0.10	0.08	0.08	0.09
a*	0.06	0.03	0.03	0.02	0.02	0.06	0.12	0.10	0.11	0.02	0.01	0.11	0.05	0.02	0.03
b*	0.12	0.08	0.06	0.06	0.04	0.10	0.10	0.12	0.07	0.11	0.11	0.13	0.10	0.04	0.06

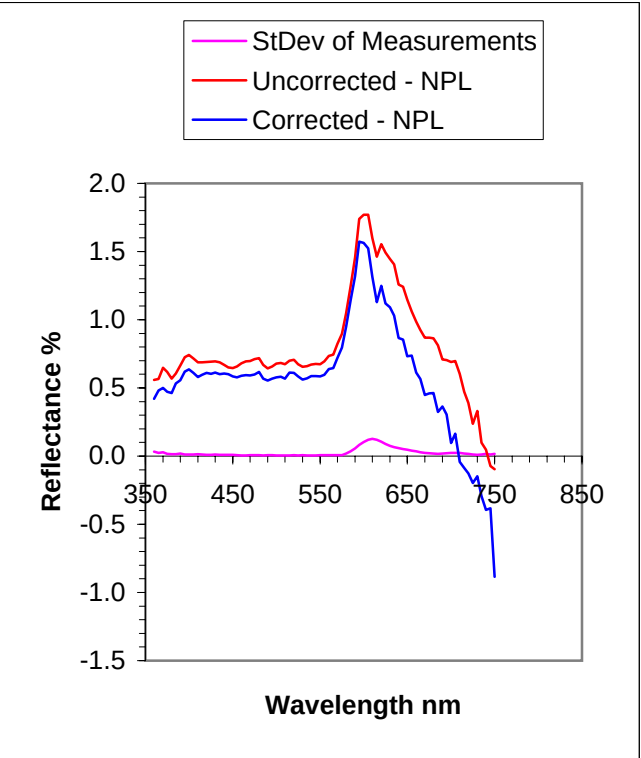
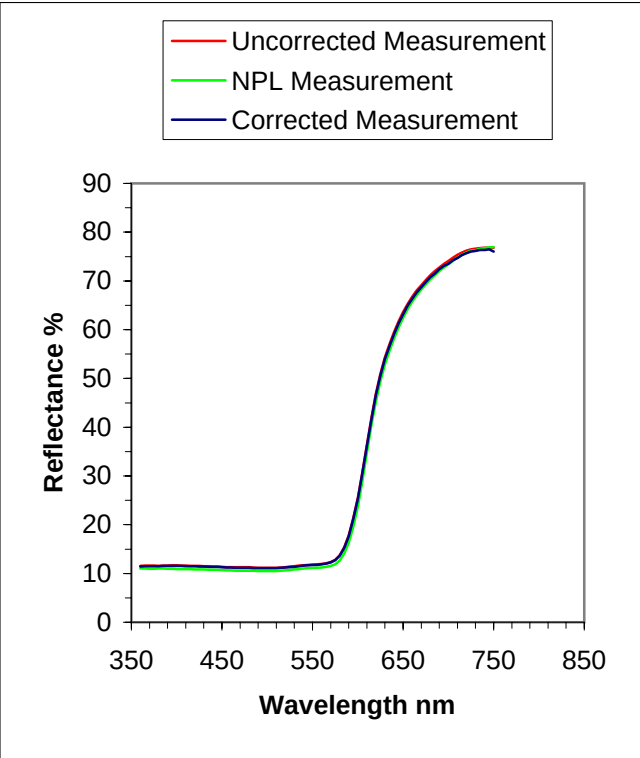
Colorimetry

			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	97.72	85.54	63.50	64.24	40.35	49.75	49.10	69.21	85.87	59.92	59.52	57.29	32.81	31.80	78.53
		a*	-0.24	-0.26	-0.17	-1.91	-0.77	22.93	36.14	34.68	-4.98	-26.58	-26.18	-10.19	6.79	-0.79	-0.21
		b*	1.49	0.18	0.02	1.59	-0.83	3.21	15.42	44.08	69.73	9.87	12.03	-27.44	-15.96	-2.43	-0.30
Average Measurement (Uncorrected)	B	L*	97.72	85.53	63.50	64.24	40.35	49.74	49.07	69.16	85.82	59.90	59.51	57.29	32.83	31.81	78.53
		a*	-0.25	-0.26	-0.18	-1.91	-0.77	22.89	36.05	34.71	-4.92	-26.52	-26.12	-10.15	6.78	-0.79	-0.20
		b*	1.49	0.17	0.03	1.59	-0.82	3.19	15.33	44.01	69.70	9.88	12.03	-27.44	-15.94	-2.43	-0.30
Average Measurement (Corrected)	C	L*	97.42	85.27	63.29	64.03	40.20	49.58	48.90	68.95	85.56	59.70	59.31	57.09	32.70	31.69	78.28
		a*	-0.18	-0.19	-0.13	-1.86	-0.73	22.88	36.00	34.66	-4.87	-26.41	-26.01	-10.06	6.80	-0.76	-0.15
		b*	1.46	0.15	0.01	1.57	-0.83	3.17	15.28	43.89	69.52	9.85	11.99	-27.40	-15.91	-2.44	-0.32
NPL Values	D	L*	95.76	84.26	61.82	62.37	38.82	48.26	47.90	68.78	85.35	58.75	58.82	56.08	31.61	31.07	76.57
		a*	-0.41	-0.36	-0.26	-1.99	-0.81	22.69	36.31	36.23	-4.66	-27.58	-27.89	-10.35	6.92	-0.80	-0.20
		b*	1.73	0.28	0.04	1.67	-0.78	3.16	15.29	45.37	71.05	10.46	12.92	-28.05	-16.03	-2.50	-0.31
A to B		dE*	0.011	0.006	0.007	0.004	0.010	0.040	0.131	0.093	0.084	0.061	0.067	0.040	0.033	0.010	0.003
B to C		dE*	0.307	0.274	0.215	0.218	0.153	0.171	0.177	0.254	0.325	0.234	0.232	0.218	0.131	0.130	0.255
B to D		dE*	1.977	1.282	1.680	1.872	1.529	1.495	1.191	2.071	1.458	1.660	2.102	1.367	1.234	0.746	1.954
C to D		dE*	1.695	1.029	1.476	1.667	1.383	1.326	1.043	2.161	1.561	1.622	2.160	1.238	1.107	0.621	1.707
Corrected + Uncertainty	E	L*	99.81	87.57	65.59	66.32	43.09	52.09	51.44	71.22	87.86	62.03	61.64	59.46	36.16	35.25	80.55
		a*	-0.03	-0.09	-0.12	-1.84	-0.58	23.47	36.88	34.77	-4.69	-26.06	-25.66	-9.81	7.65	-0.50	-0.06
		b*	1.73	0.36	0.03	1.60	-0.43	3.28	15.57	44.42	69.82	9.86	12.02	-27.33	-14.48	-1.58	-0.16
Corrected - Uncertainty	F	L*	95.03	82.97	60.99	61.73	37.31	47.06	46.37	66.68	83.26	57.37	56.97	54.72	29.24	28.12	76.01
		a*	-0.32	-0.30	-0.14	-1.87	-0.88	22.28	35.12	34.55	-5.04	-26.76	-26.35	-10.32	5.95	-1.01	-0.23
		b*	1.19	-0.06	-0.01	1.55	-1.23	3.07	15.00	43.36	69.22	9.83	11.96	-27.46	-17.34	-3.29	-0.48

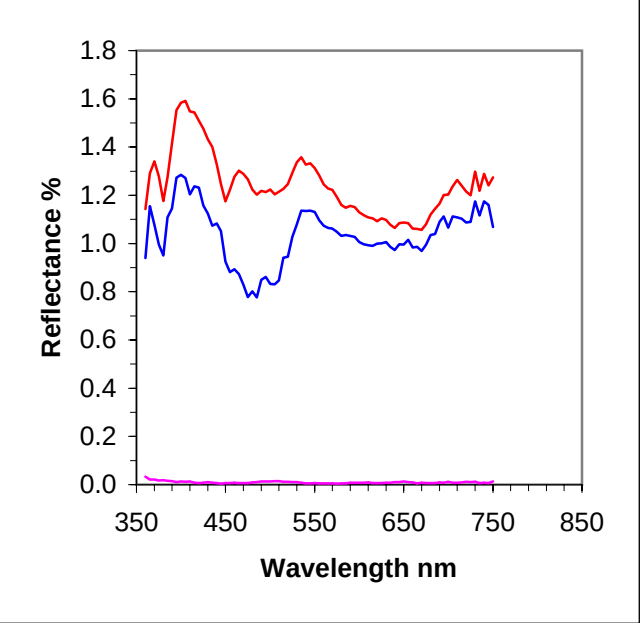
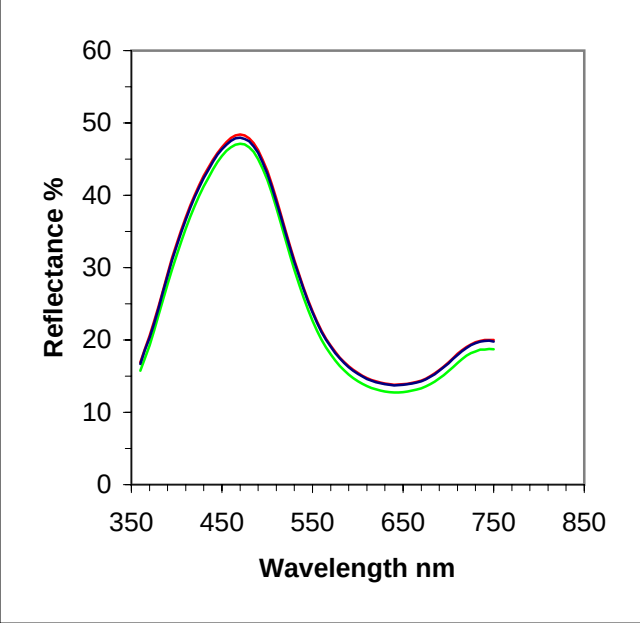




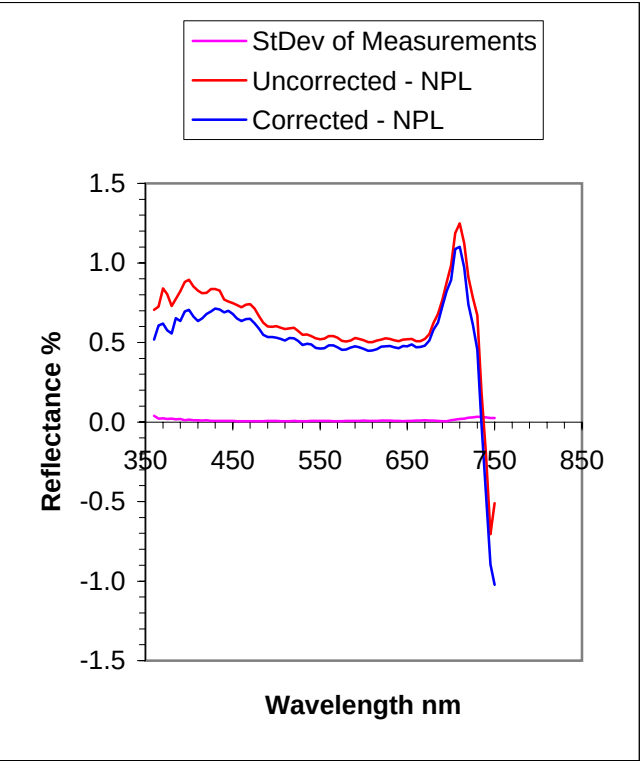
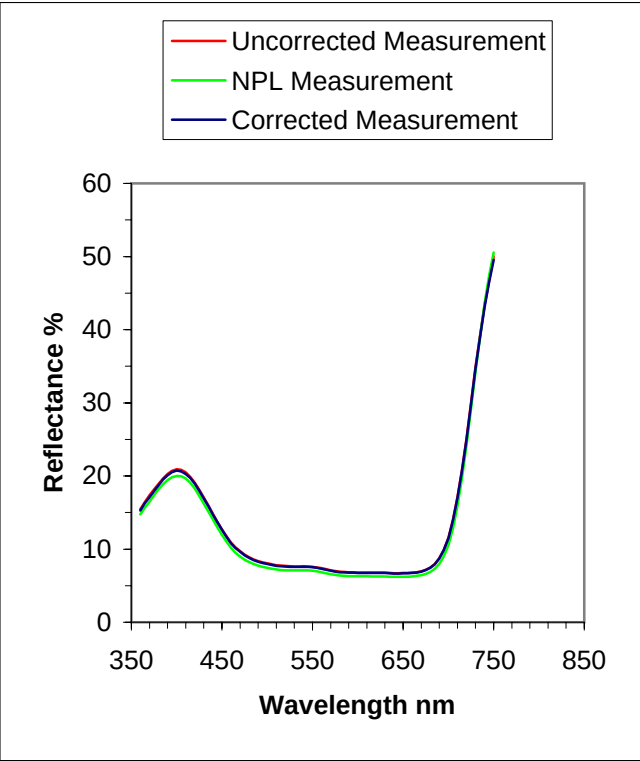




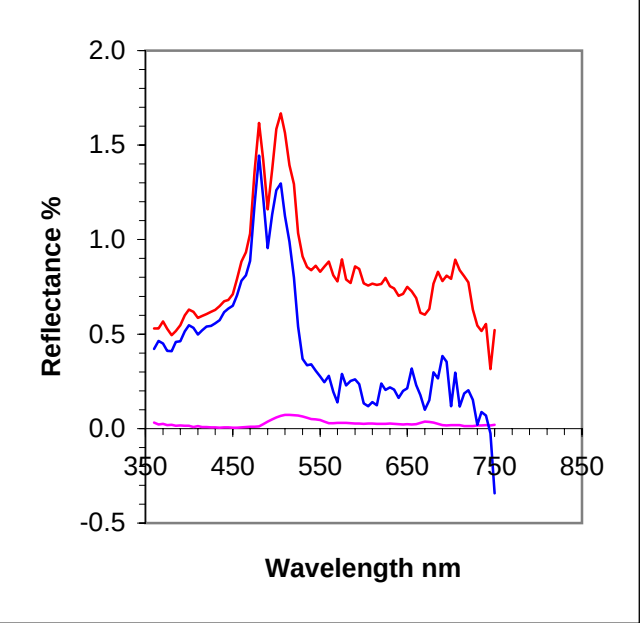
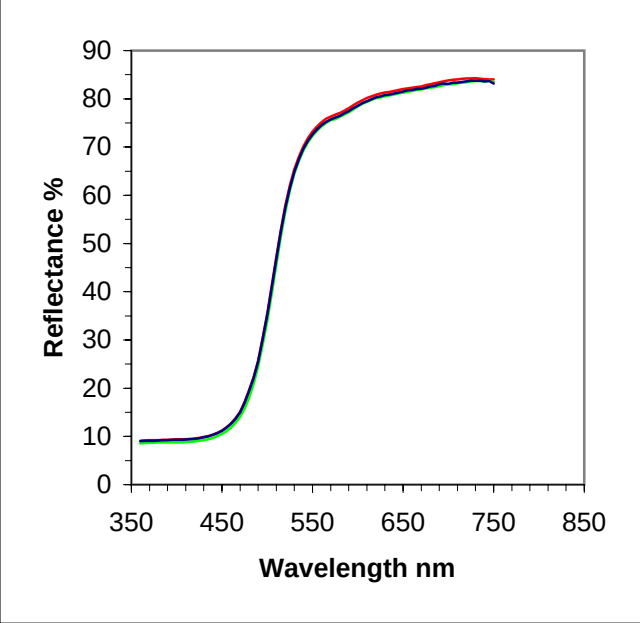
**Red
Matt**



**Cyan
Matt**



**Blue
Matt**



**Yellow
Matt**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 2

Aperture: Normal

Geometry: 45°/0°

Tiles: Gloss

NPL Master Tiles: Colours CCS3

White WT56

Black BT03

Grey GT51

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0116	R%	+	0.2586
450 nm	Uncert =	0.0234	R%	+	0.0887
500 nm	Uncert =	0.0138	R%	+	0.0959
550 nm	Uncert =	0.0127	R%	+	0.0668
600 nm	Uncert =	0.0125	R%	+	0.0684
650 nm	Uncert =	0.0135	R%	+	0.1698
700 nm	Uncert =	0.0129	R%	+	0.3008

<= 460 nm Uncert = **0.025** R% + **0.250** (k = 2)

>= 465 nm Uncert = **0.015** R% + **0.250** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	0.63	2.32
a*	0.17	2.15
b*	0.28	1.82

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0257	R%	+	0.3944
450 nm	Uncert =	0.0091	R%	+	0.0770
500 nm	Uncert =	0.0081	R%	+	0.0917
550 nm	Uncert =	0.0073	R%	+	0.1144
600 nm	Uncert =	0.0077	R%	+	0.0953
650 nm	Uncert =	0.0080	R%	+	0.1973
700 nm	Uncert =	0.0116	R%	+	0.1720

<= 460 nm Uncert = **0.025** R% + **0.400** (k = 2)

>= 460 nm Uncert = **0.010** R% + **0.200** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	0.46	1.87
a*	0.34	1.05
b*	0.70	2.53

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.61	1.16	0.63	0.64	0.32	0.43	0.41	0.77	1.18	0.56	0.57	0.54	0.27	0.26	0.98
x	0.0004	0.0004	0.0005	0.0004	0.0008	0.0026	0.0075	0.0022	0.0010	0.0005	0.0004	0.0010	0.0091	0.0305	0.0004
y	0.0009	0.0009	0.0009	0.0010	0.0012	0.0003	0.0004	0.0009	0.0011	0.0023	0.0024	0.0001	0.0162	0.0006	0.0009
L*	0.67	0.63	0.62	0.62	0.95	0.70	0.73	0.62	0.63	0.63	0.63	0.64	2.06	2.32	0.62
a*	0.21	0.18	0.14	0.14	0.07	0.16	0.42	0.12	0.16	0.29	0.27	0.36	2.15	< 0.01	0.17
b*	0.40	0.36	0.27	0.27	0.20	0.28	1.46	0.69	0.35	0.25	0.27	0.27	1.82	0.06	0.34

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

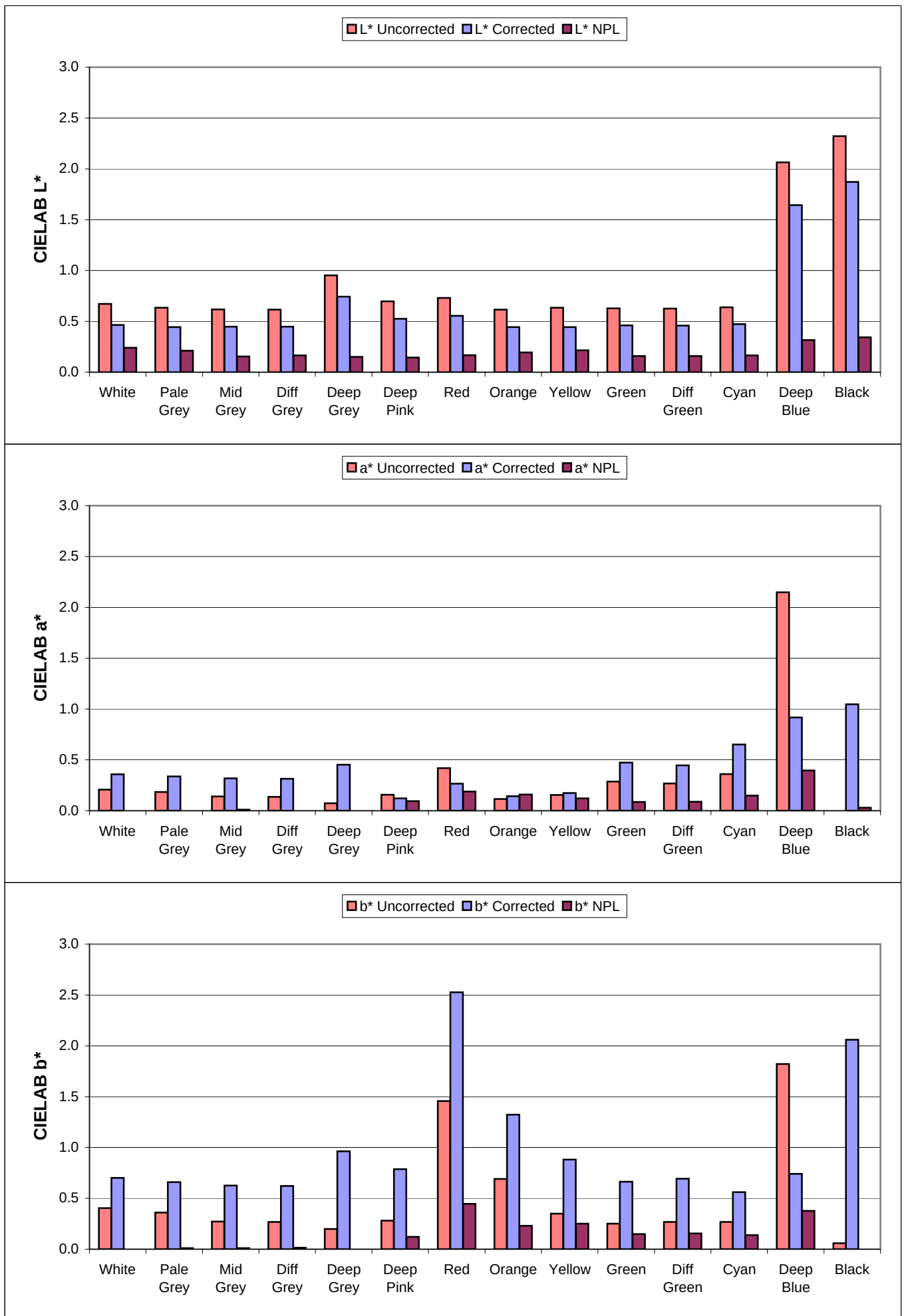
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.10	0.81	0.46	0.46	0.25	0.32	0.31	0.55	0.82	0.41	0.41	0.40	0.22	0.21	0.69
x	0.0008	0.0008	0.0010	0.0010	0.0030	0.0037	0.0088	0.0027	0.0012	0.0004	0.0005	0.0006	0.0063	0.0118	0.0008
y	0.0015	0.0017	0.0021	0.0022	0.0057	0.0021	0.0023	0.0017	0.0016	0.0039	0.0040	0.0013	0.0103	0.0923	0.0017
L*	0.47	0.44	0.45	0.45	0.74	0.53	0.56	0.44	0.44	0.46	0.46	0.47	1.64	1.87	0.44
a*	0.36	0.34	0.32	0.31	0.45	0.12	0.27	0.14	0.17	0.47	0.45	0.65	0.92	1.05	0.33
b*	0.70	0.66	0.63	0.62	0.96	0.79	2.53	1.32	0.88	0.66	0.69	0.56	0.74	2.06	0.64

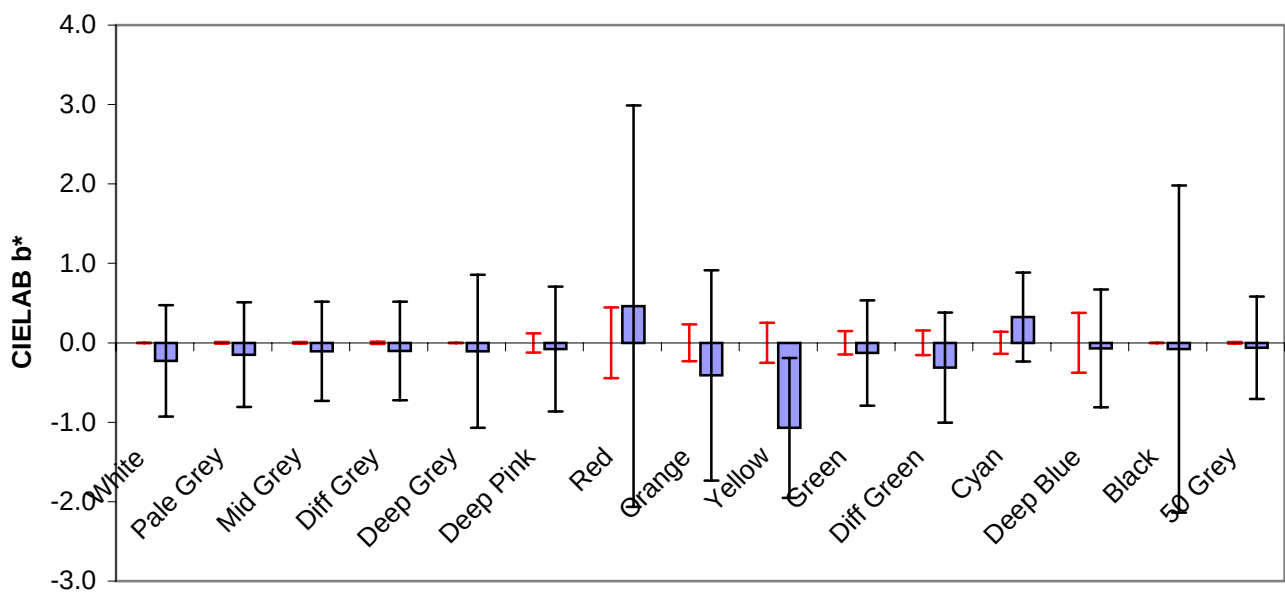
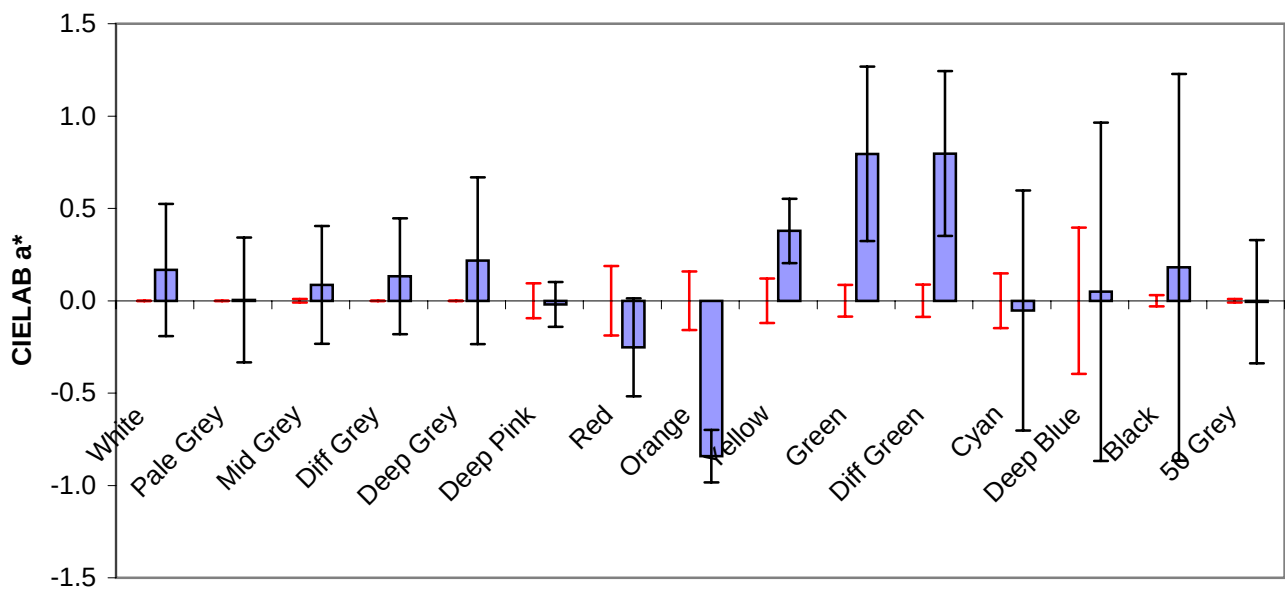
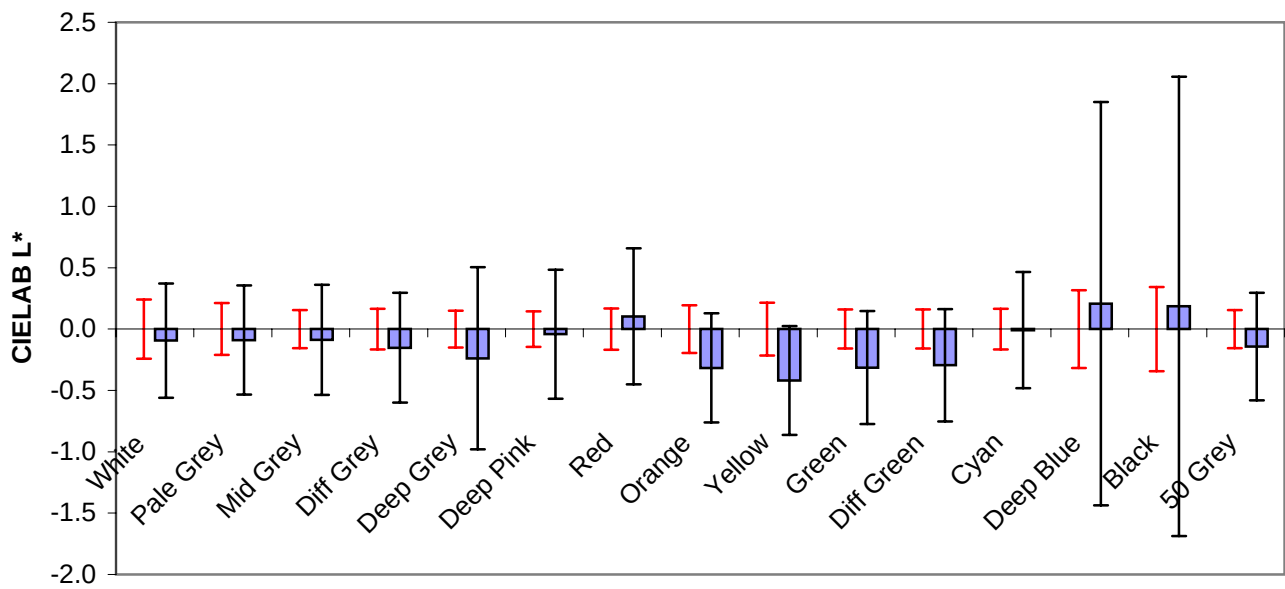
NPL Lambda Uncertainty

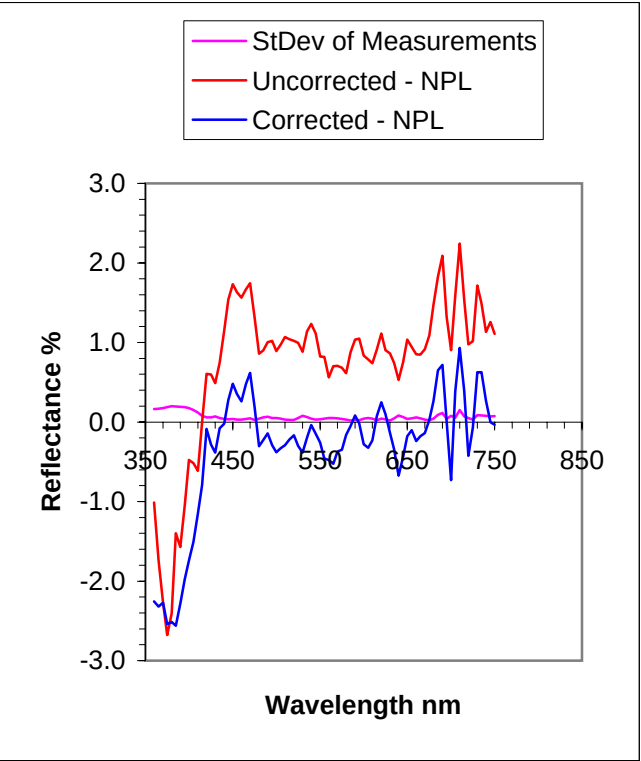
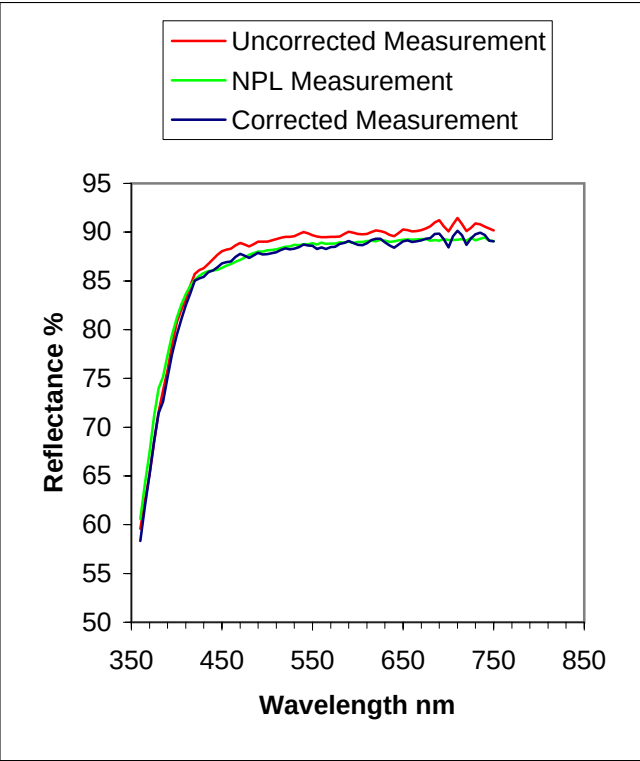
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.57	0.39	0.16	0.16	0.05	0.08	0.08	0.24	0.40	0.14	0.14	0.14	0.04	0.04	0.16
x	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0006	0.0016	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	< 0.0001
y	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0001	0.0004	0.0001	0.0006	0.0005	0.0005	0.0026	0.0001	< 0.0001
L*	0.24	0.21	0.16	0.16	0.15	0.14	0.17	0.19	0.21	0.16	0.16	0.17	0.32	0.34	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.09	0.19	0.16	0.12	0.09	0.09	0.15	0.40	0.03	0.01
b*	< 0.01	0.01	0.01	0.01	< 0.01	0.12	0.45	0.23	0.25	0.15	0.15	0.14	0.38	< 0.01	0.01

Colorimetry

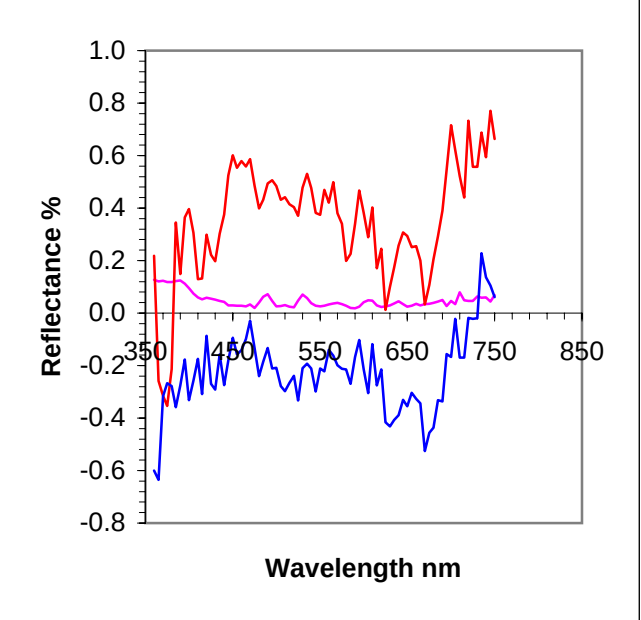
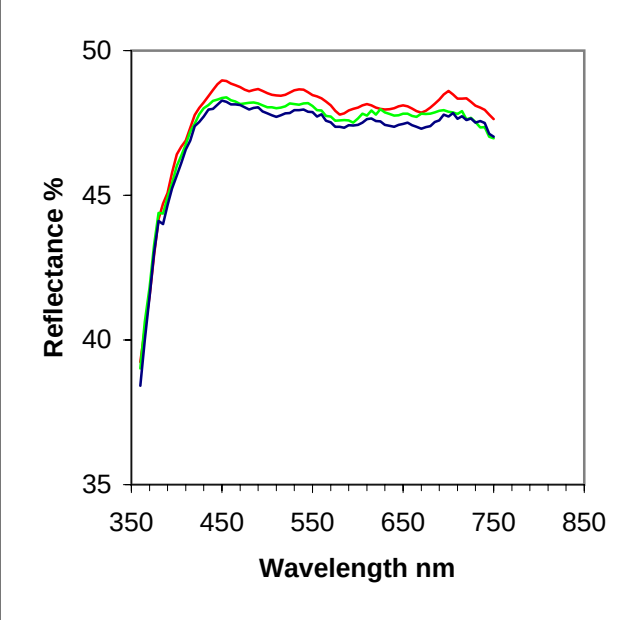
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	95.81	81.92	57.30	57.78	26.54	40.88	38.05	64.81	82.76	52.39	53.06	50.54	11.08	4.19	74.99
		a*	-0.38	-0.49	-0.11	-2.46	0.17	29.04	53.00	40.99	-4.10	-34.83	-34.48	-13.44	20.96	-1.39	-0.32
		b*	1.31	0.46	0.41	2.55	1.21	4.84	37.89	62.75	83.01	15.99	19.46	-32.74	-31.57	-0.68	-0.30
Average Measurement (Uncorrected)	B	L*	95.83	81.96	57.35	57.76	26.57	40.89	38.06	64.81	82.74	52.40	53.07	50.57	11.11	4.17	75.02
		a*	-0.40	-0.52	-0.15	-2.46	0.18	29.04	52.96	40.96	-4.08	-34.82	-34.49	-13.46	20.97	-1.42	-0.32
		b*	1.32	0.48	0.45	2.50	1.23	4.83	37.89	62.76	82.98	16.00	19.45	-32.73	-31.53	-0.57	-0.32
Average Measurement (Corrected)	C	L*	95.36	81.54	57.04	57.44	26.39	40.66	37.85	64.49	82.33	52.10	52.76	50.27	10.99	4.12	74.63
		a*	-0.25	-0.39	-0.06	-2.35	0.23	28.98	52.78	40.85	-3.93	-34.57	-34.24	-13.31	20.92	-1.39	-0.20
		b*	1.33	0.49	0.46	2.49	1.23	4.83	37.76	62.54	82.66	15.93	19.37	-32.60	-31.42	-0.57	-0.31
NPL Values	D	L*	95.45	81.63	57.13	57.60	26.63	40.70	37.74	64.81	82.75	52.42	53.06	50.28	10.79	3.93	74.78
		a*	-0.42	-0.39	-0.14	-2.49	0.01	29.00	53.03	41.69	-4.31	-35.37	-35.03	-13.26	20.87	-1.57	-0.20
		b*	1.56	0.64	0.57	2.60	1.34	4.91	37.30	62.95	83.73	16.06	19.68	-32.93	-31.35	-0.48	-0.24
A to B		dE*	0.035	0.054	0.085	0.057	0.034	0.011	0.039	0.029	0.042	0.014	0.015	0.030	0.046	0.111	0.029
B to C		dE*	0.498	0.436	0.326	0.332	0.189	0.240	0.303	0.398	0.541	0.397	0.401	0.355	0.171	0.064	0.405
B to D		dE*	0.448	0.384	0.251	0.192	0.203	0.209	0.669	0.756	0.787	0.549	0.594	0.401	0.386	0.295	0.284
C to D		dE*	0.297	0.174	0.164	0.227	0.339	0.091	0.537	0.988	1.210	0.864	0.905	0.330	0.224	0.272	0.156
Corrected + Uncertainty	E	L*	95.82	81.99	57.49	57.89	27.13	41.18	38.40	64.94	82.77	52.56	53.22	50.74	12.64	5.99	75.07
		a*	0.10	-0.05	0.26	-2.04	0.68	29.10	53.05	40.99	-3.76	-34.10	-33.79	-12.66	21.84	-0.34	0.13
		b*	2.03	1.15	1.09	3.12	2.19	5.61	40.29	63.87	83.54	16.59	20.06	-32.04	-30.68	1.49	0.34
Corrected - Uncertainty	F	L*	94.89	81.10	56.59	57.00	25.65	40.13	37.29	64.05	81.89	51.64	52.30	49.80	9.35	2.25	74.19
		a*	-0.61	-0.72	-0.38	-2.67	-0.22	28.86	52.52	40.71	-4.11	-35.04	-34.68	-13.96	20.01	-2.43	-0.54
		b*	0.63	-0.17	-0.16	1.87	0.27	4.04	35.24	61.22	81.78	15.27	18.68	-33.16	-32.16	-2.62	-0.95



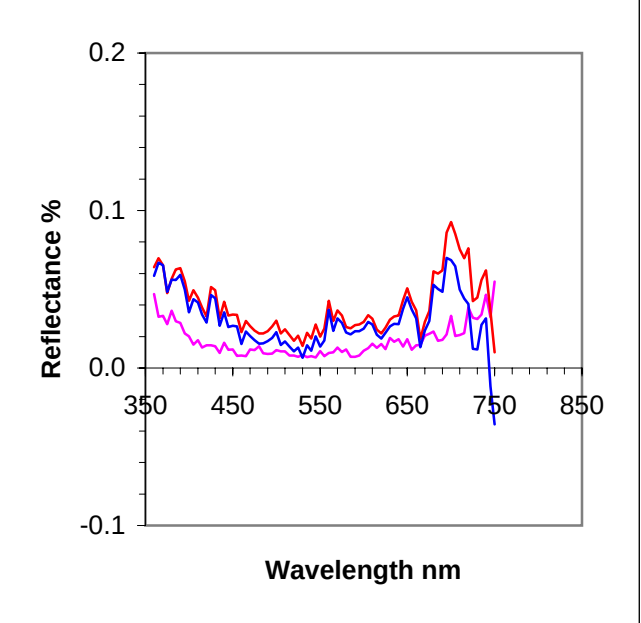
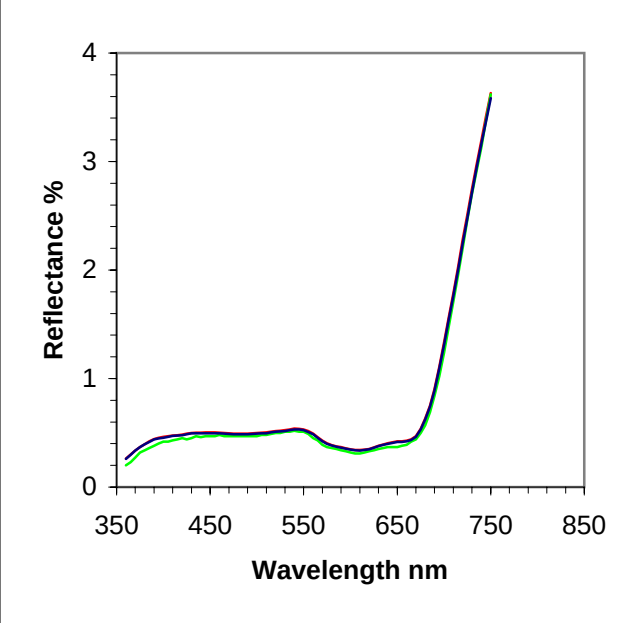




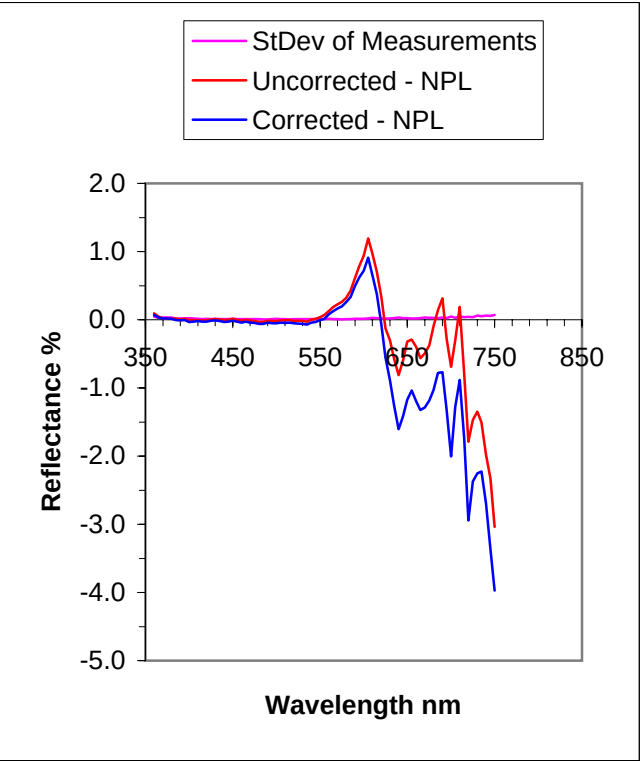
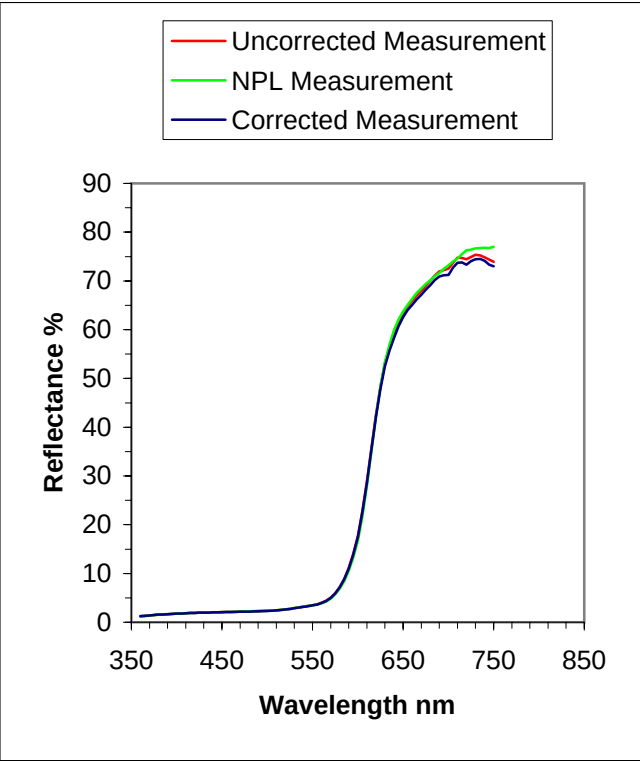
**White
Gloss**



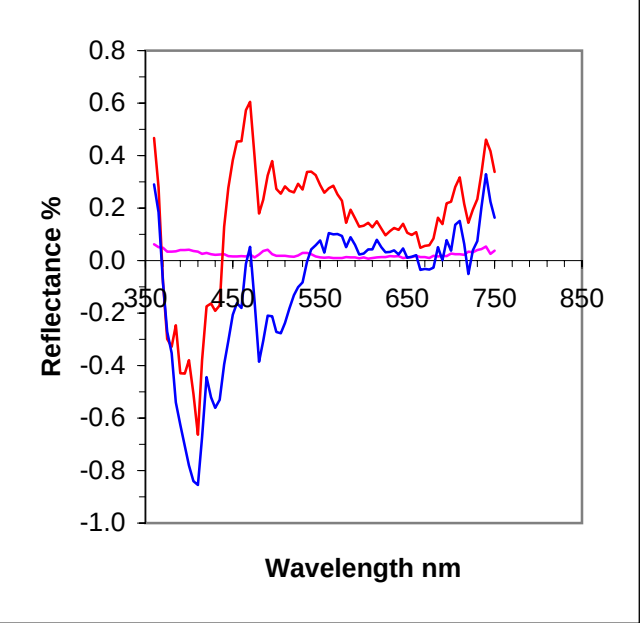
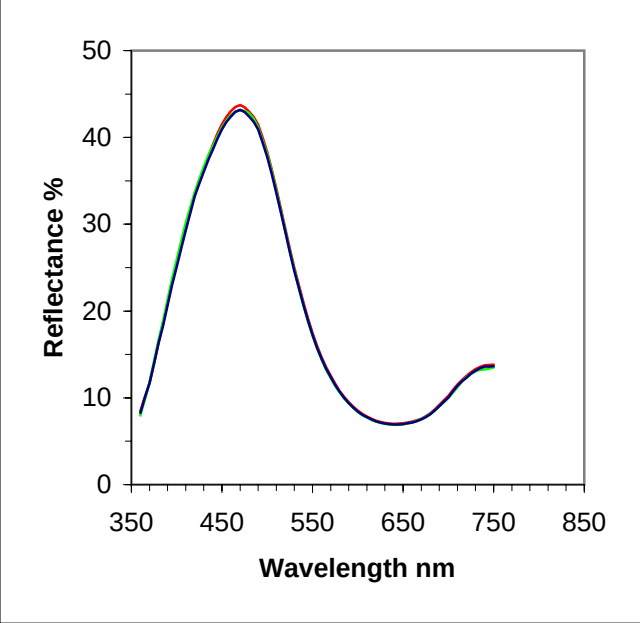
**50 Grey
Gloss**



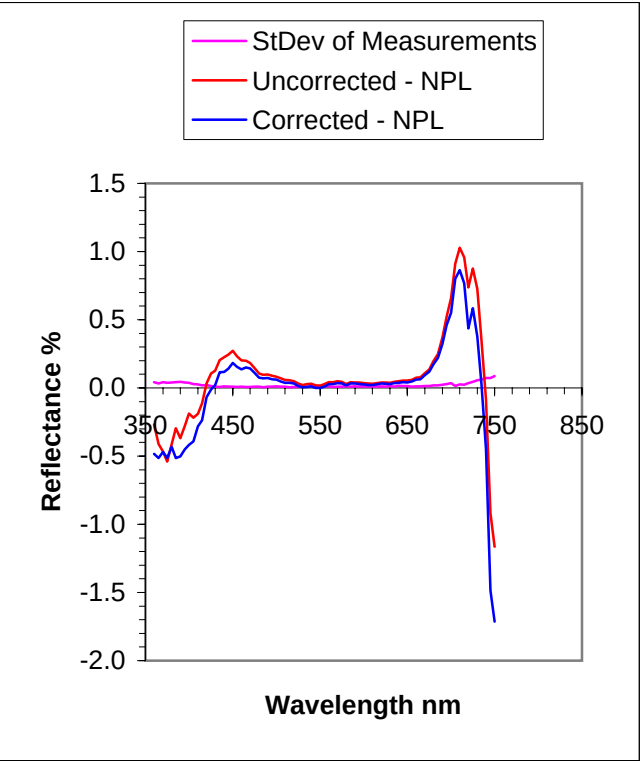
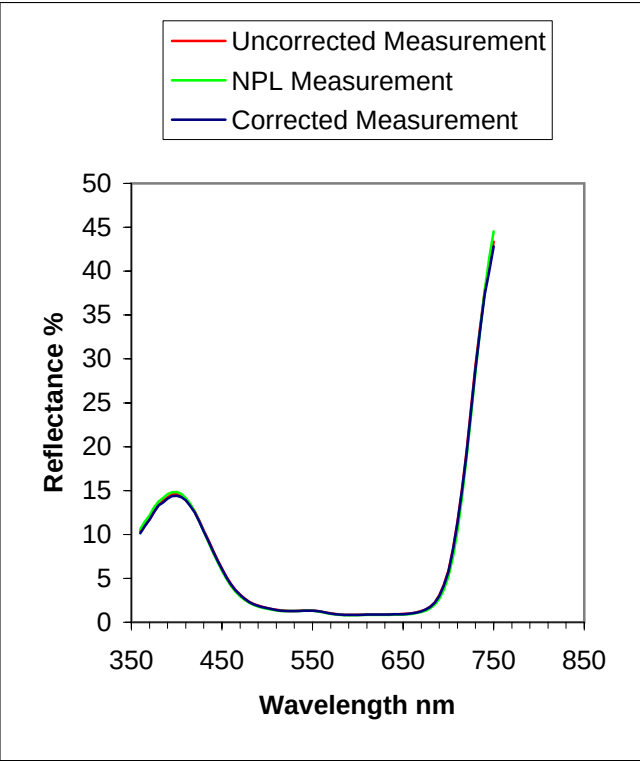
**Black
Gloss**



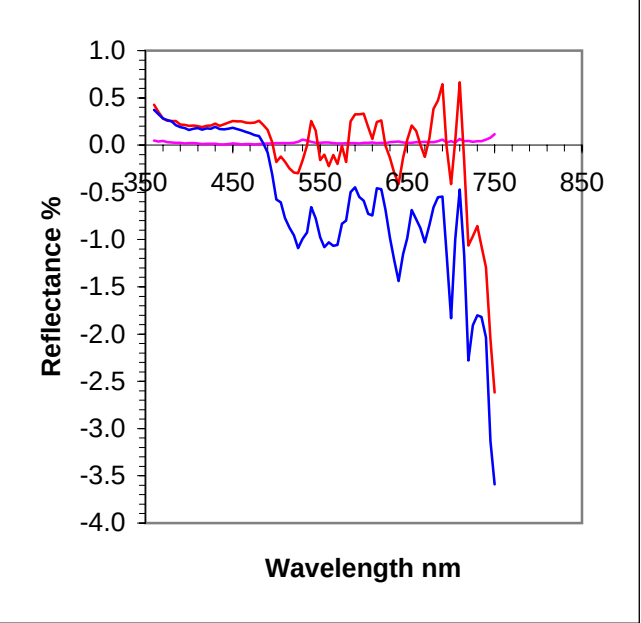
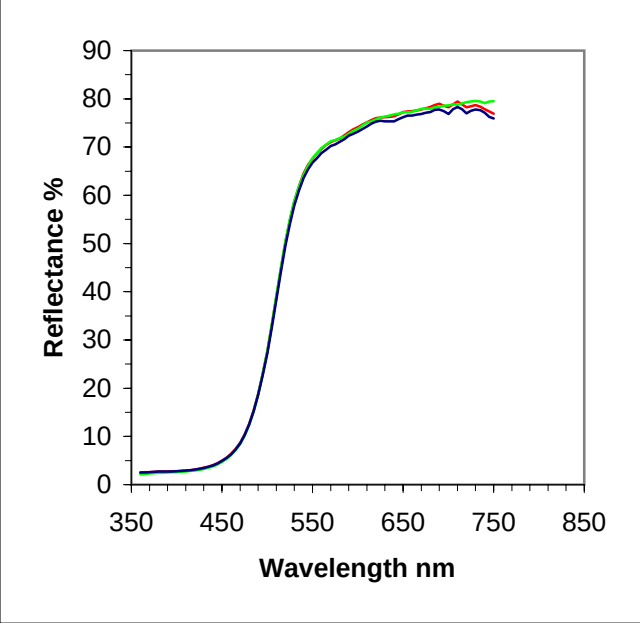
**Red
Gloss**



**Cyan
Gloss**



**Blue
Gloss**



**Yellow
Gloss**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 2

Aperture: Normal

Geometry: 45°/0°

Tiles: Matt

NPL Master Tiles: Colours CCM6

White WT45

Black BT10

Grey GT41

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0130	R%	+	0.8592
450 nm	Uncert =	0.0253	R%	+	0.5228
500 nm	Uncert =	0.0174	R%	+	0.2410
550 nm	Uncert =	0.0159	R%	+	0.1395
600 nm	Uncert =	0.0162	R%	+	0.1327
650 nm	Uncert =	0.0180	R%	+	0.2655
700 nm	Uncert =	0.0159	R%	+	0.4266

<= 460 nm Uncert = **0.025** R% + **0.900** (k = 2)

>= 465 nm Uncert = **0.020** R% + **0.400** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	0.89	1.36
a*	0.32	0.83
b*	0.80	1.39

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0133	R%	+	0.5799
450 nm	Uncert =	0.0153	R%	+	0.0487
500 nm	Uncert =	0.0128	R%	+	0.1118
550 nm	Uncert =	0.0122	R%	+	0.1944
600 nm	Uncert =	0.0124	R%	+	0.3428
650 nm	Uncert =	0.0116	R%	+	0.3590
700 nm	Uncert =	0.0108	R%	+	0.3066

<= 460 nm Uncert = **0.016** R% + **0.600** (k = 2)

>= 460 nm Uncert = **0.013** R% + **0.400** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	0.71	1.24
a*	0.15	0.39
b*	0.40	0.84

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	2.24	1.71	1.02	1.02	0.61	0.74	0.73	1.18	1.75	0.94	0.94	0.89	0.54	0.53	1.43
x	0.0005	0.0006	0.0010	0.0010	0.0022	0.0036	0.0066	0.0038	0.0020	0.0005	0.0006	0.0008	0.0002	0.0029	0.0006
y	0.0010	0.0012	0.0020	0.0021	0.0050	0.0025	0.0030	0.0025	0.0027	0.0041	0.0044	0.0007	0.0007	0.0074	0.0013
L*	0.93	0.89	0.88	0.88	1.10	0.96	0.97	0.87	0.89	0.89	0.89	0.90	1.32	1.36	0.87
a*	0.22	0.24	0.32	0.33	0.60	0.20	0.18	0.23	0.21	0.54	0.54	0.51	0.48	0.83	0.26
b*	0.43	0.48	0.63	0.64	1.09	0.92	1.39	1.31	1.12	0.80	0.85	0.48	0.61	1.39	0.51

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

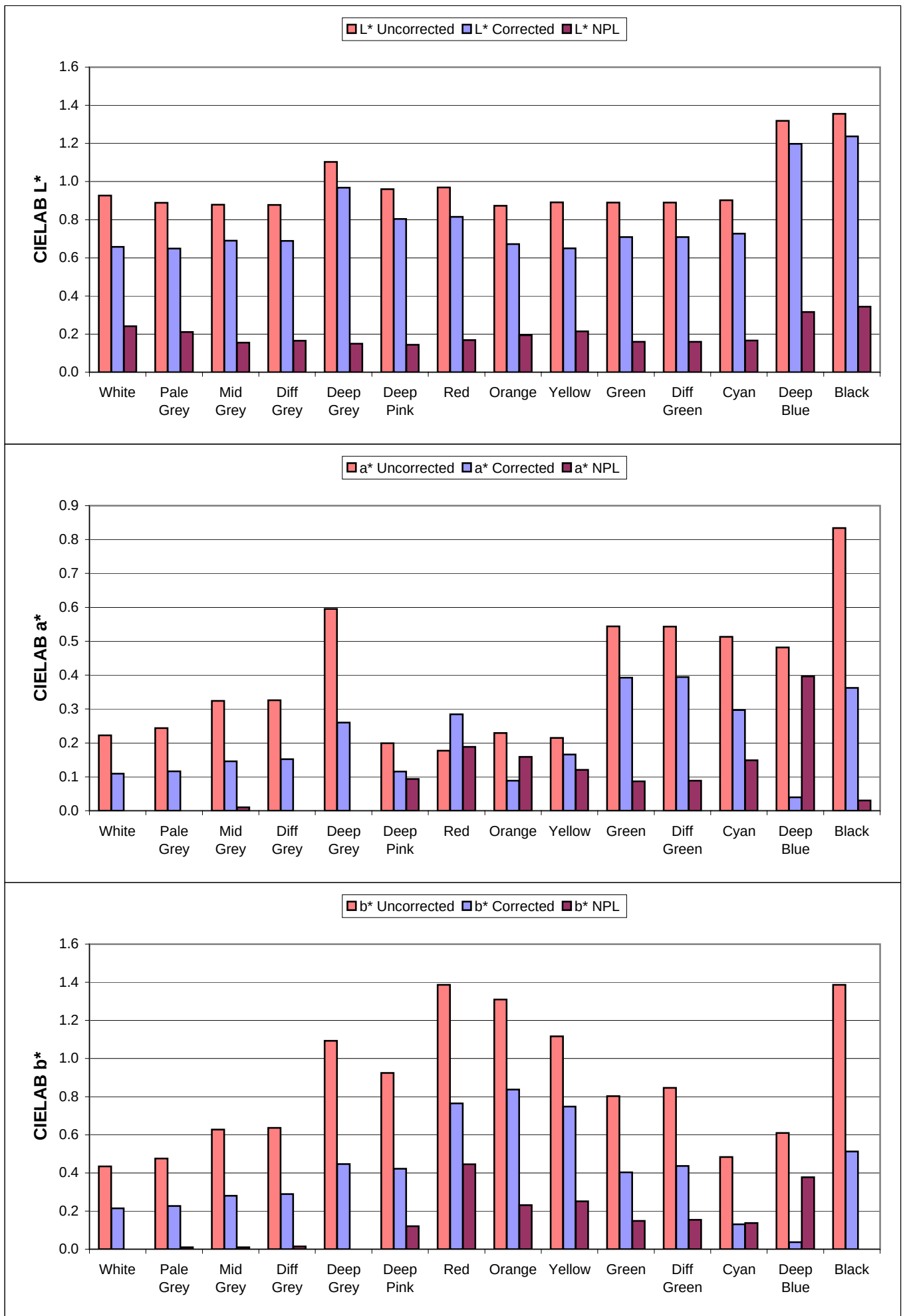
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.58	1.24	0.80	0.80	0.53	0.62	0.61	0.91	1.27	0.74	0.74	0.71	0.49	0.48	1.06
x	0.0002	0.0003	0.0004	0.0004	0.0008	0.0024	0.0049	0.0028	0.0014	0.0003	0.0003	0.0011	0.0015	0.0007	0.0003
y	0.0005	0.0006	0.0009	0.0010	0.0020	0.0008	0.0012	0.0015	0.0018	0.0024	0.0026	0.0002	0.0020	0.0027	0.0006
L*	0.66	0.65	0.69	0.69	0.97	0.80	0.82	0.67	0.65	0.71	0.71	0.73	1.20	1.24	0.65
a*	0.11	0.12	0.15	0.15	0.26	0.12	0.28	0.09	0.17	0.39	0.39	0.30	0.04	0.36	0.12
b*	0.21	0.23	0.28	0.29	0.45	0.42	0.76	0.84	0.75	0.40	0.44	0.13	0.04	0.51	0.24

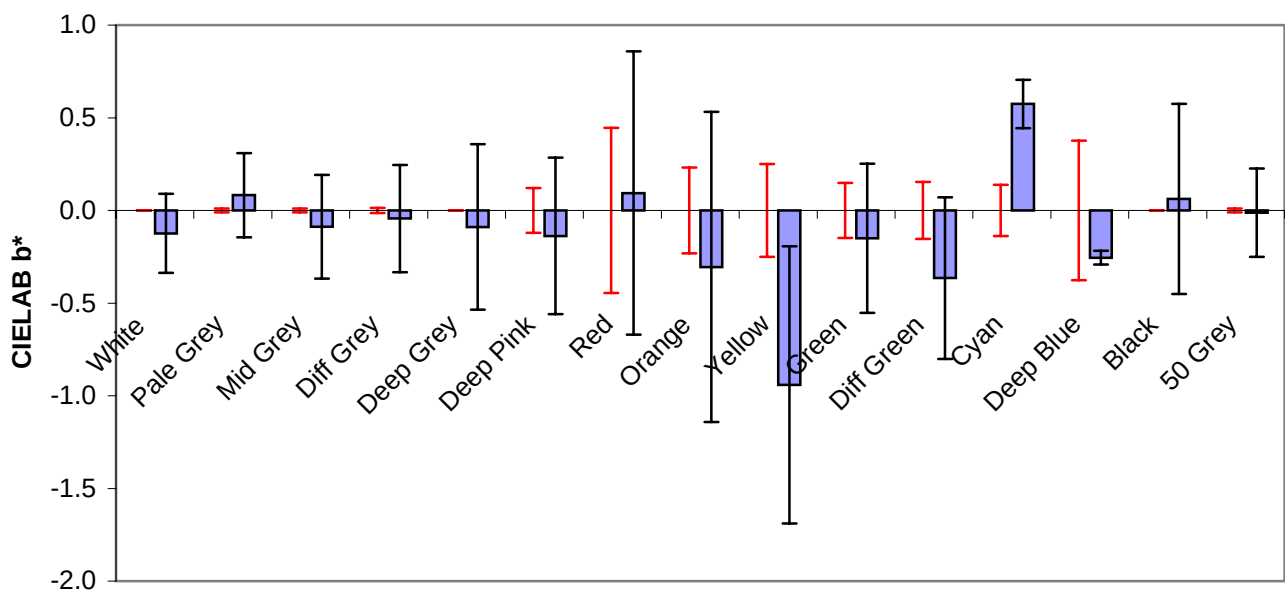
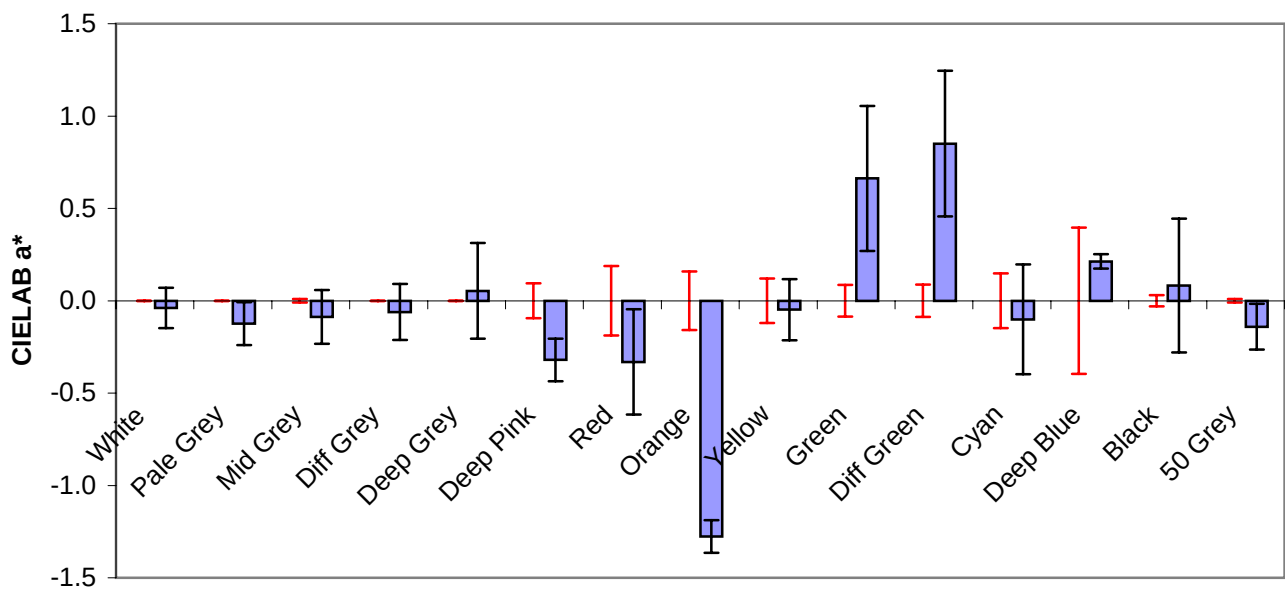
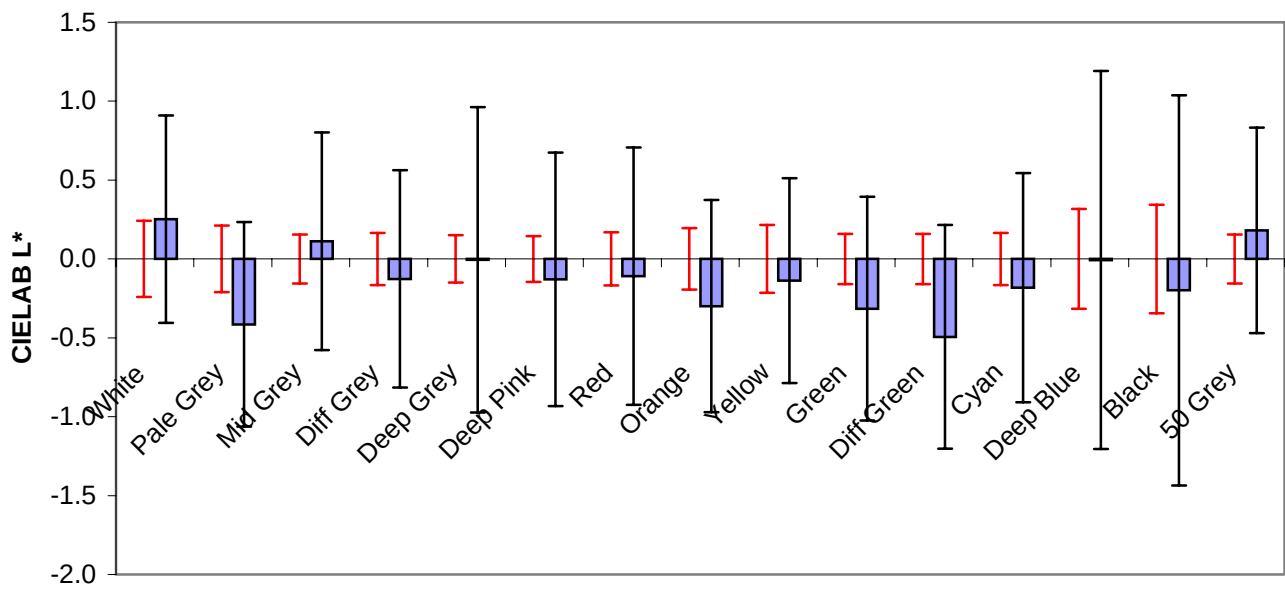
NPL Lambda Uncertainty

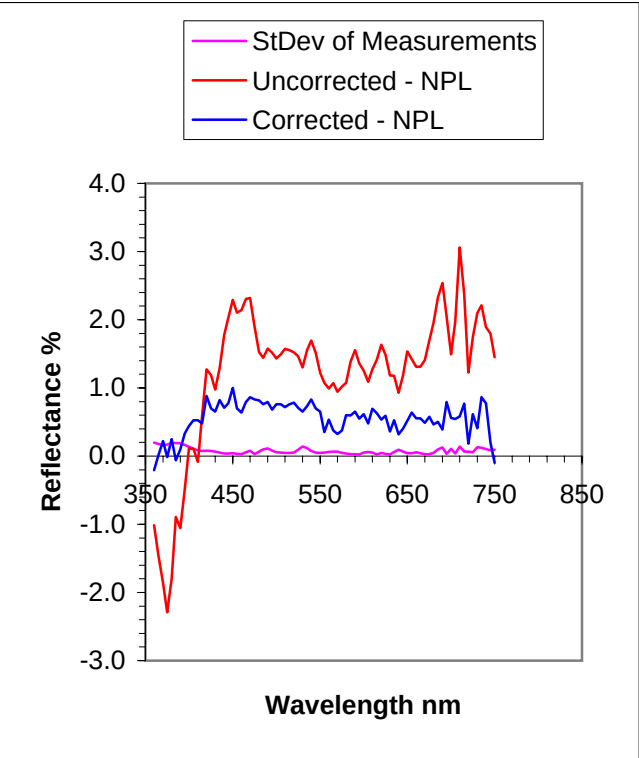
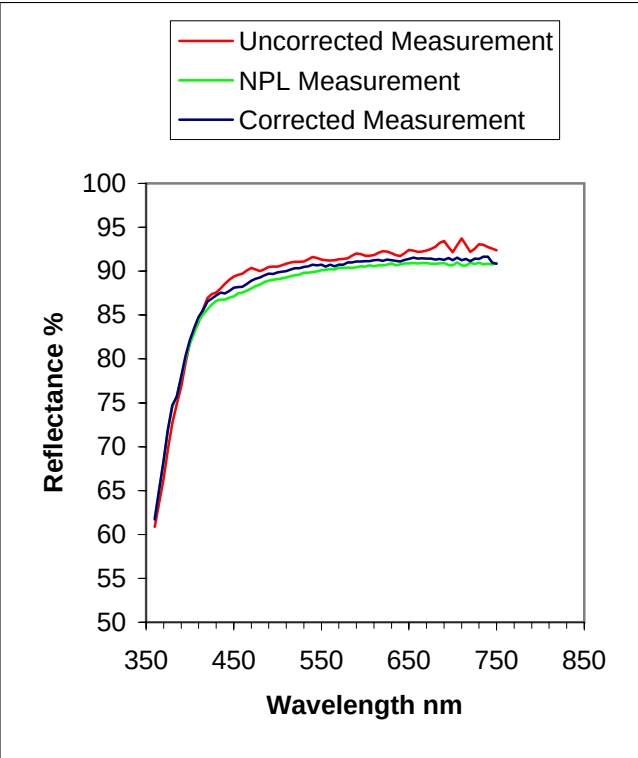
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.57	0.39	0.16	0.16	0.05	0.08	0.08	0.24	0.40	0.14	0.14	0.14	0.04	0.04	0.16
x	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0006	0.0016	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	< 0.0001
y	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0001	0.0004	0.0001	0.0006	0.0005	0.0005	0.0026	0.0001	< 0.0001
L*	0.24	0.21	0.16	0.16	0.15	0.14	0.17	0.19	0.21	0.16	0.16	0.17	0.32	0.34	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.09	0.19	0.16	0.12	0.09	0.09	0.15	0.40	0.03	0.01
b*	< 0.01	0.01	0.01	0.01	< 0.01	0.12	0.45	0.23	0.25	0.15	0.15	0.14	0.38	< 0.01	0.01

Colorimetry

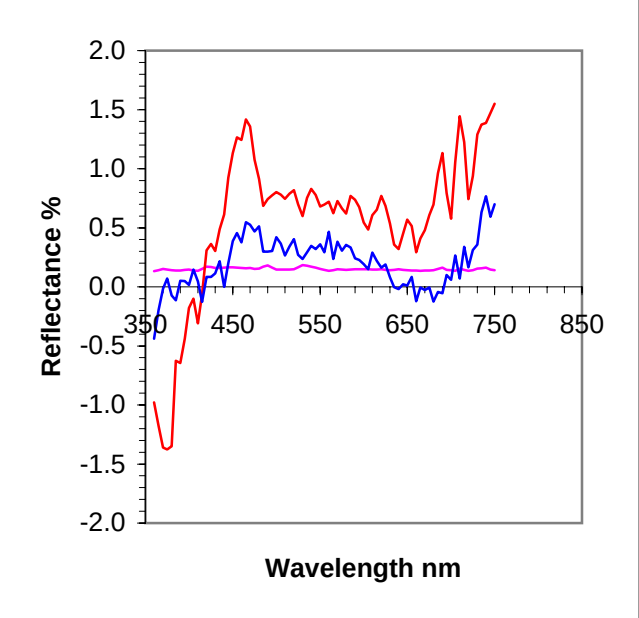
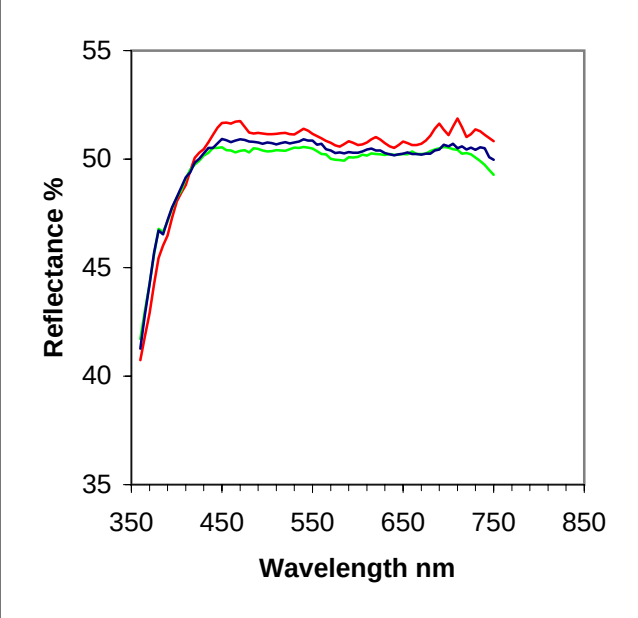
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	96.52	84.37	62.04	62.47	38.25	47.84	47.07	68.37	85.52	58.46	58.49	56.00	30.82	29.74	76.92
		a*	-0.21	-0.36	-0.21	-2.05	-0.62	22.91	36.73	36.13	-4.27	-27.61	-27.85	-11.04	7.68	-0.65	-0.32
		b*	1.54	0.26	0.00	1.86	-0.81	2.80	15.67	45.97	71.88	10.98	13.45	-27.70	-17.07	-2.32	-0.23
Average Measurement (Uncorrected)	B	L*	96.55	84.47	62.05	62.36	38.26	47.85	47.10	68.28	85.50	58.44	58.45	56.00	30.73	29.77	76.68
		a*	-0.26	-0.35	-0.23	-1.99	-0.66	22.91	36.72	36.11	-4.26	-27.58	-27.77	-11.03	7.71	-0.67	-0.29
		b*	1.57	0.30	0.01	1.70	-0.81	2.81	15.67	45.75	71.83	10.95	13.38	-27.70	-17.08	-2.34	-0.23
Average Measurement (Corrected)	C	L*	96.25	84.20	61.84	62.15	38.11	47.67	46.92	68.06	85.23	58.24	58.25	55.80	30.60	29.65	76.43
		a*	-0.34	-0.43	-0.29	-2.05	-0.71	22.80	36.58	35.97	-4.29	-27.55	-27.74	-11.10	7.65	-0.70	-0.37
		b*	1.78	0.50	0.16	1.85	-0.70	2.90	15.72	45.75	71.75	11.05	13.47	-27.45	-16.96	-2.25	-0.05
NPL Values	D	L*	96.00	84.61	61.72	62.28	38.12	47.80	47.03	68.36	85.37	58.55	58.74	55.98	30.61	29.85	76.25
		a*	-0.31	-0.31	-0.21	-1.98	-0.76	23.12	36.91	37.24	-4.24	-28.22	-28.59	-11.00	7.43	-0.79	-0.23
		b*	1.90	0.41	0.25	1.89	-0.61	3.04	15.63	46.05	72.69	11.21	13.84	-28.03	-16.70	-2.31	-0.04
A to B		dE*	0.059	0.104	0.024	0.198	0.041	0.013	0.031	0.229	0.053	0.043	0.115	0.012	0.095	0.044	0.244
B to C		dE*	0.380	0.341	0.266	0.263	0.185	0.229	0.234	0.265	0.279	0.227	0.223	0.327	0.189	0.160	0.316
B to D		dE*	0.650	0.186	0.401	0.208	0.259	0.317	0.200	1.173	0.872	0.694	0.985	0.328	0.484	0.146	0.476
C to D		dE*	0.283	0.441	0.167	0.147	0.104	0.372	0.361	1.346	0.952	0.749	1.049	0.611	0.333	0.225	0.230
Corrected + Uncertainty	E	L*	96.91	84.84	62.53	62.84	39.08	48.48	47.74	68.73	85.88	58.95	58.96	56.52	31.80	30.89	77.08
		a*	-0.24	-0.31	-0.15	-1.89	-0.45	22.92	36.86	36.06	-4.12	-27.16	-27.35	-10.81	7.69	-0.34	-0.24
		b*	1.99	0.72	0.44	2.14	-0.26	3.33	16.49	46.59	72.50	11.46	13.91	-27.32	-16.92	-1.73	0.19
Corrected - Uncertainty	F	L*	95.59	83.55	61.15	61.46	37.14	46.87	46.11	67.39	84.58	57.53	57.54	55.07	29.40	28.41	75.78
		a*	-0.45	-0.55	-0.44	-2.20	-0.97	22.68	36.29	35.88	-4.45	-27.95	-28.13	-11.40	7.61	-1.07	-0.49
		b*	1.56	0.27	-0.12	1.56	-1.15	2.48	14.96	44.91	71.00	10.65	13.03	-27.58	-16.99	-2.76	-0.29



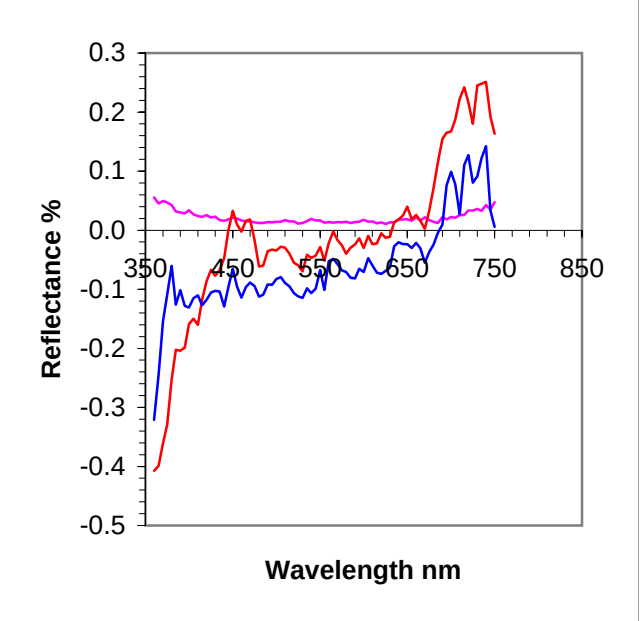
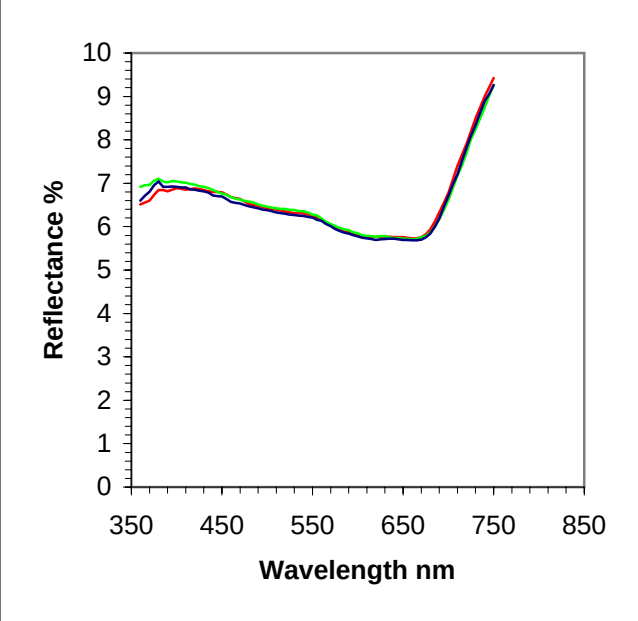




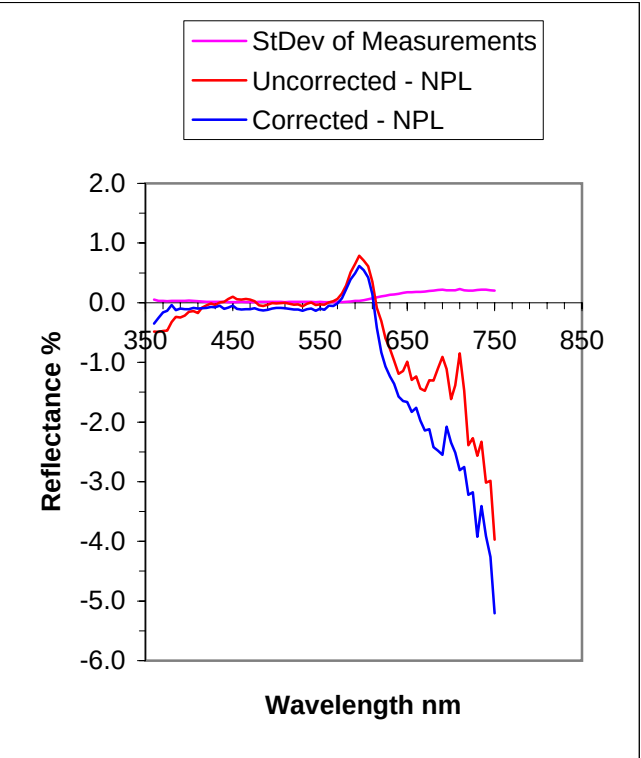
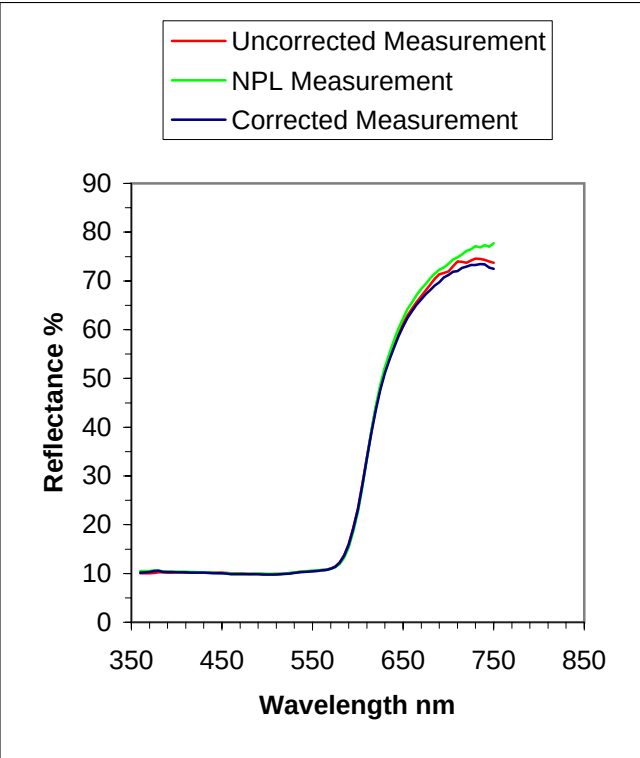
**White
Matt**



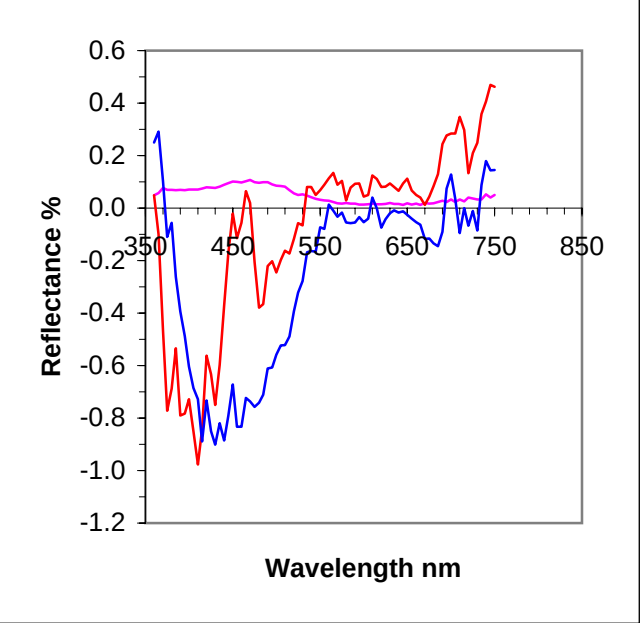
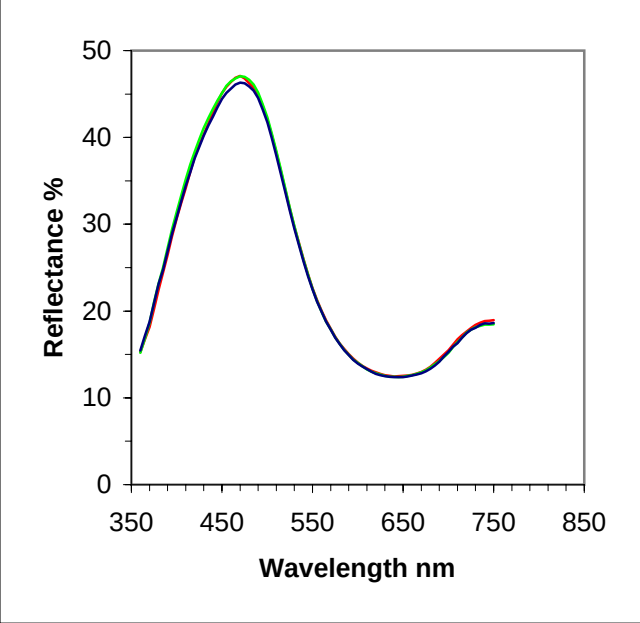
**50 Grey
Matt**



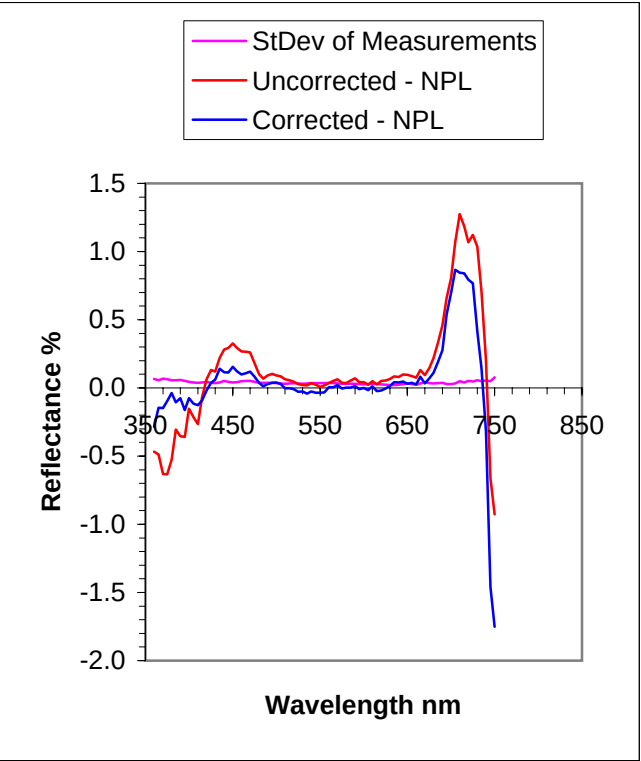
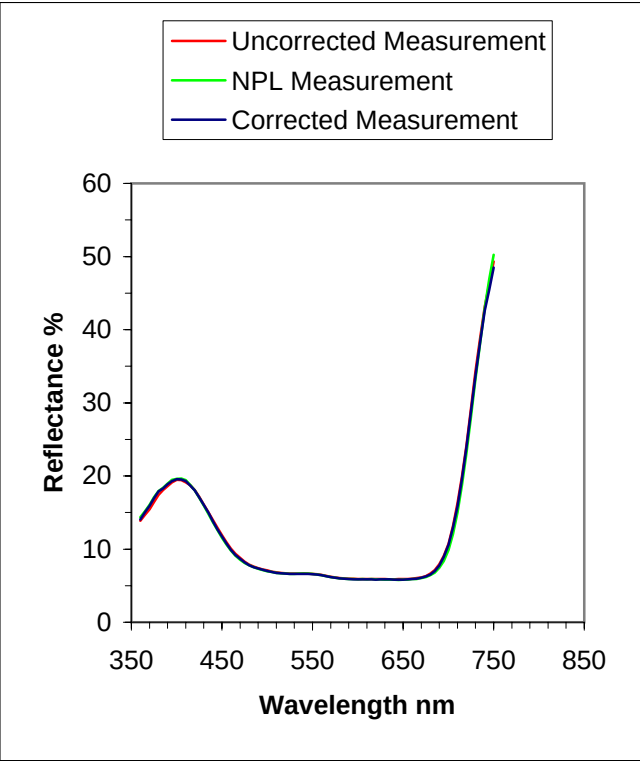
**Black
Matt**



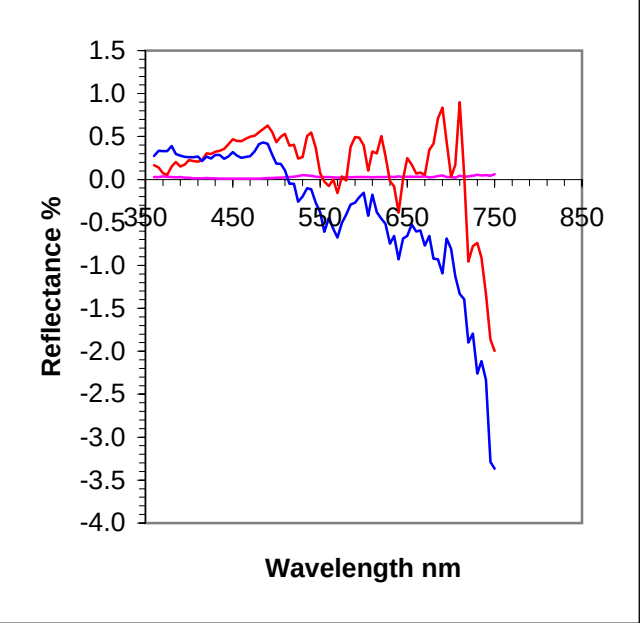
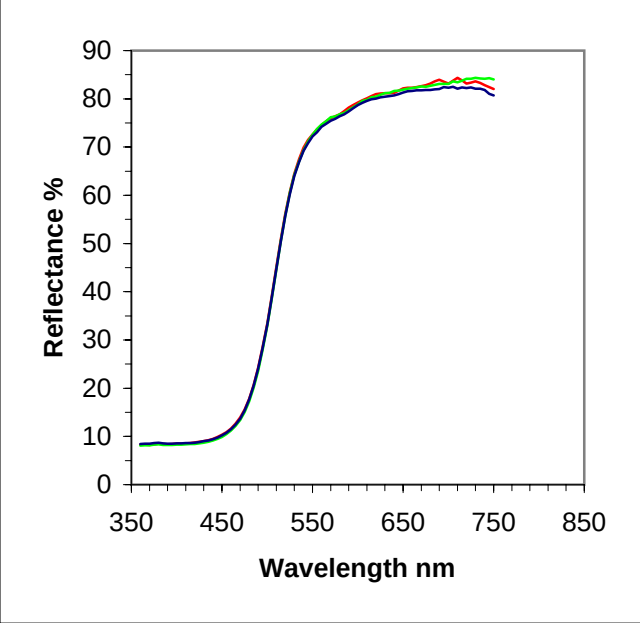
Red
Matt



Cyan
Matt



Blue
Matt



Yellow
Matt

INSTRUMENT CHARACTERISATION

Instrument: Instrument 3

Aperture: Normal

Geometry: 45°/0°

Tiles: Gloss

NPL Master Tiles: Colours CCS3

White WT56

Black BT03

Grey GT51

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0296	R%	+	0.6918	
450 nm	Uncert =	0.0148	R%	+	0.3289	
500 nm	Uncert =	0.0122	R%	+	0.4638	
550 nm	Uncert =	0.0124	R%	+	0.3639	
600 nm	Uncert =	0.0142	R%	+	0.4334	
650 nm	Uncert =	0.0122	R%	+	0.4007	
700 nm	Uncert =	0.0194	R%	+	0.2476	
<= 460 nm	Uncert =	0.030	R%	+	0.700	(k = 2)
>= 465 nm	Uncert =	0.020	R%	+	0.500	(k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	1.03	4.63
a*	0.31	4.42
b*	0.78	4.56

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0196	R%	+	0.0752	
450 nm	Uncert =	0.0092	R%	+	0.2289	
500 nm	Uncert =	0.0117	R%	+	0.1549	
550 nm	Uncert =	0.0139	R%	+	0.1605	
600 nm	Uncert =	0.0121	R%	+	0.1432	
650 nm	Uncert =	0.0138	R%	+	0.1460	
700 nm	Uncert =	0.0114	R%	+	0.1892	
<= 460 nm	Uncert =	0.02	R%	+	0.240	(k = 2)
>= 460 nm	Uncert =	0.015	R%	+	0.180	(k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	0.58	1.70
a*	0.15	1.30
b*	0.24	1.33

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	2.30	1.72	1.02	1.02	0.60	0.74	0.71	1.19	1.75	0.92	0.92	0.89	0.53	0.51	1.48
x	0.0006	0.0006	0.0008	0.0008	0.0034	0.0058	0.0177	0.0050	0.0021	0.0007	0.0003	0.0020	0.0206	0.0818	0.0006
y	0.0011	0.0012	0.0017	0.0019	0.0061	0.0013	0.0025	0.0024	0.0027	0.0053	0.0058	0.0002	0.0357	0.2231	0.0013
L*	0.97	0.94	0.99	0.99	1.79	1.21	1.28	0.95	0.94	1.03	1.03	1.06	4.38	4.63	0.94
a*	0.26	0.25	0.25	0.26	0.43	0.31	0.85	0.11	0.17	0.74	0.70	0.63	4.42	1.06	0.25
b*	0.50	0.48	0.50	0.51	0.99	0.78	4.56	2.09	1.34	0.72	0.81	0.28	3.84	2.04	0.48

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

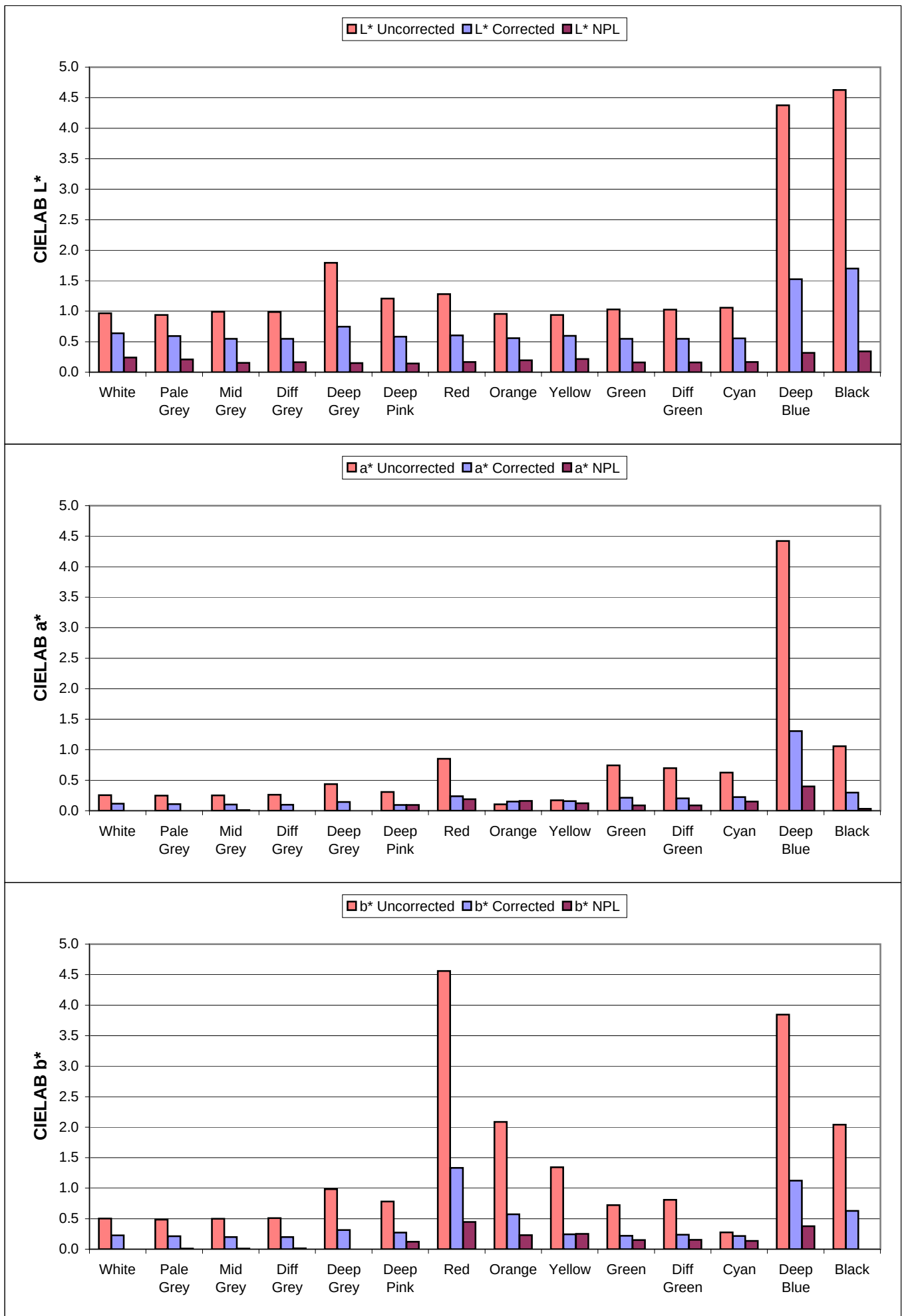
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	1.50	1.08	0.56	0.57	0.25	0.36	0.34	0.70	1.11	0.49	0.49	0.46	0.20	0.19	0.90
x	0.0003	0.0003	0.0003	0.0003	0.0011	0.0021	0.0061	0.0018	0.0008	0.0004	0.0003	0.0007	0.0066	0.0100	0.0003
y	0.0005	0.0005	0.0007	0.0007	0.0019	0.0005	0.0008	0.0009	0.0010	0.0019	0.0021	< 0.0001	0.0113	0.0190	0.0006
L*	0.64	0.59	0.55	0.55	0.75	0.58	0.61	0.56	0.60	0.55	0.55	0.55	1.52	1.70	0.57
a*	0.12	0.11	0.10	0.10	0.14	0.09	0.24	0.15	0.16	0.21	0.20	0.22	1.30	0.30	0.11
b*	0.23	0.21	0.20	0.20	0.31	0.27	1.33	0.57	0.25	0.22	0.24	0.22	1.12	0.63	0.21

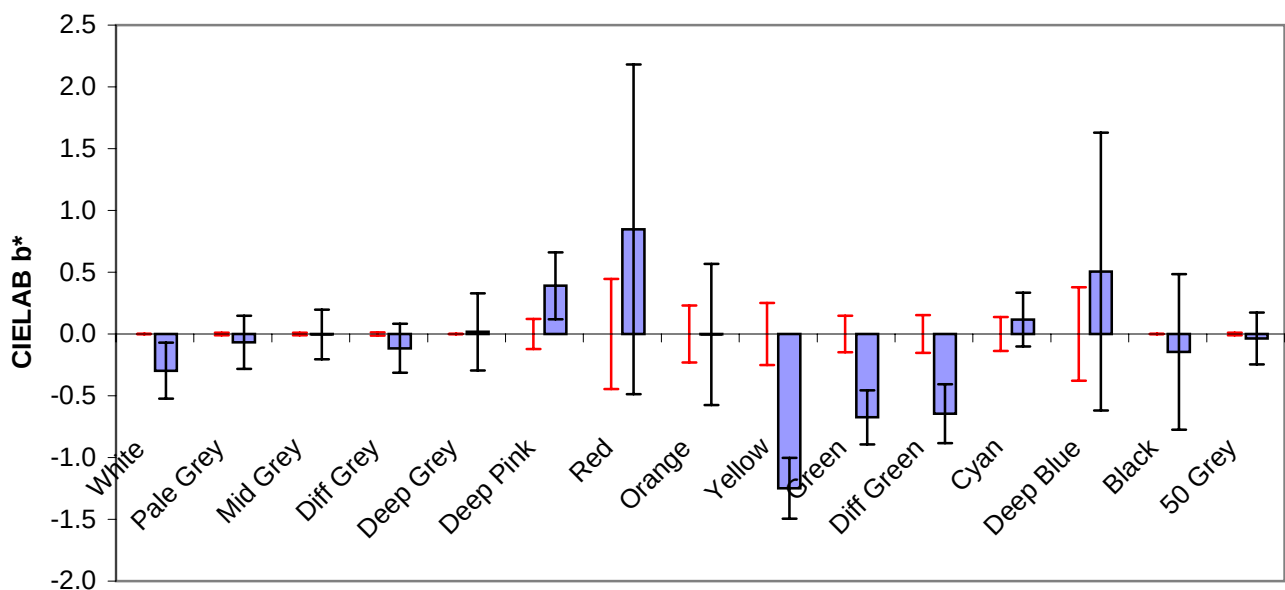
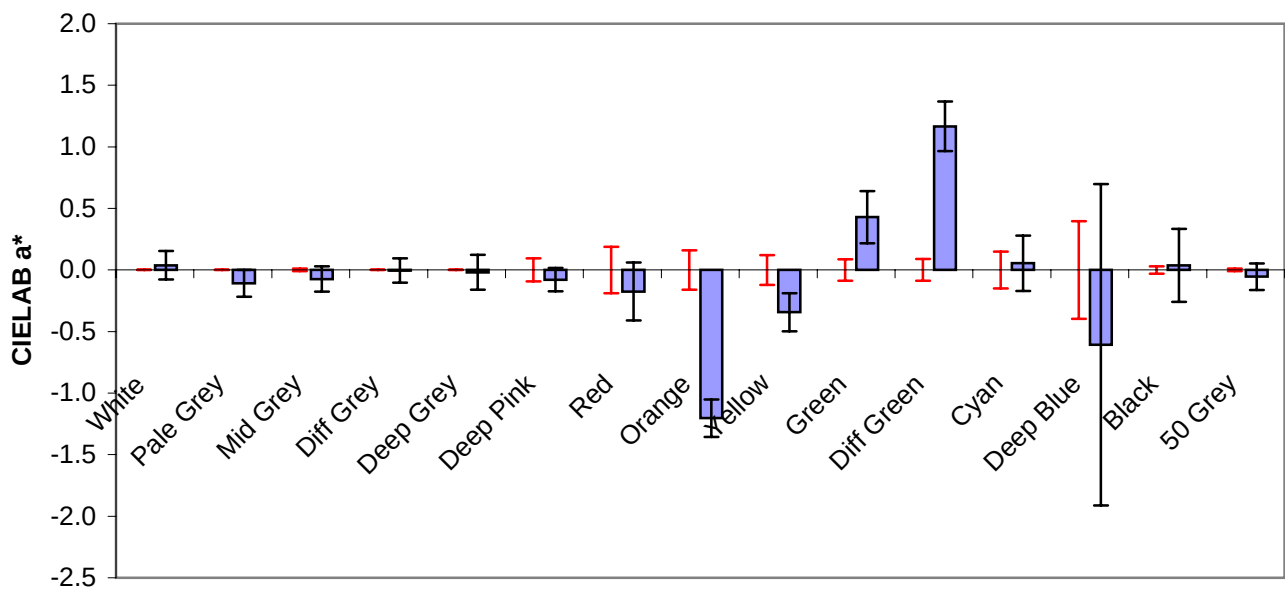
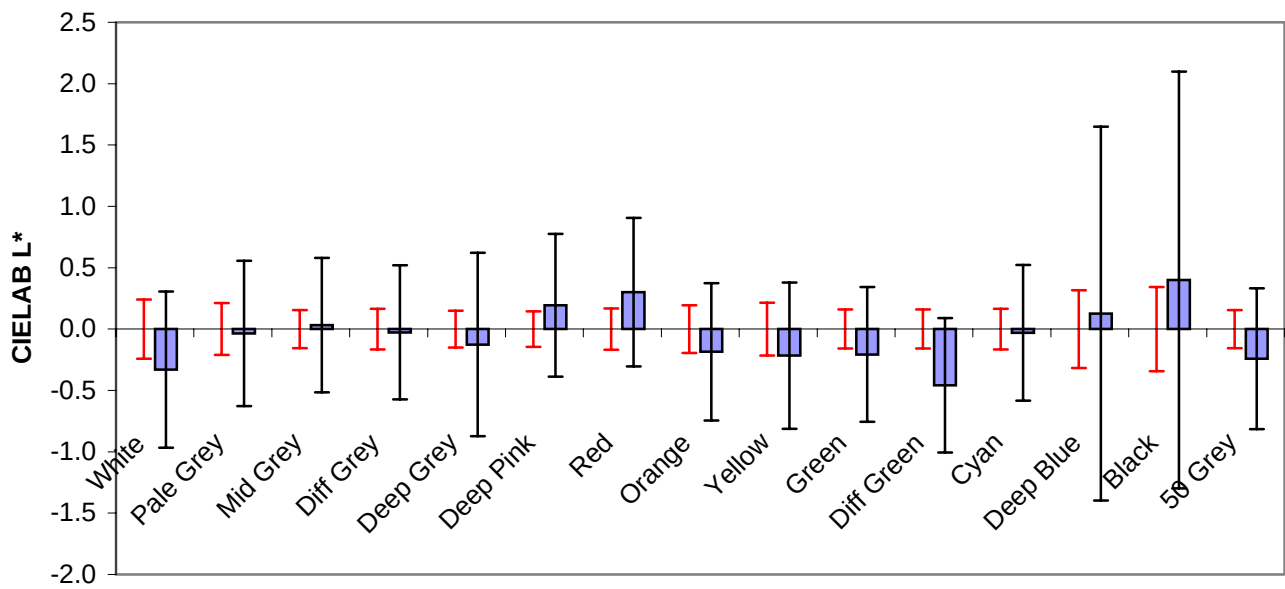
NPL Lambda Uncertainty

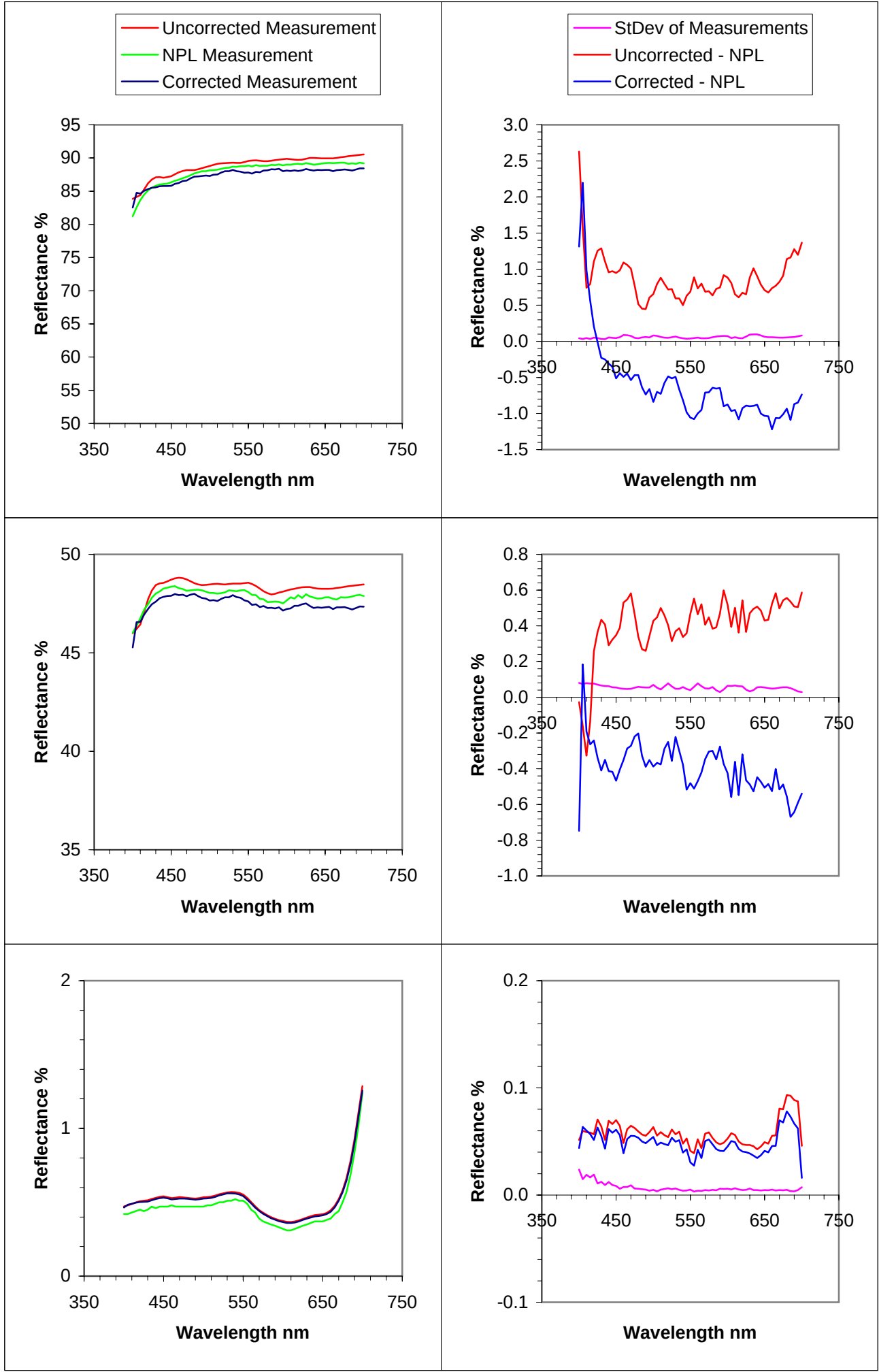
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.57	0.39	0.16	0.16	0.05	0.08	0.08	0.24	0.40	0.14	0.14	0.14	0.04	0.04	0.16
x	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0006	0.0016	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	< 0.0001
y	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0001	0.0004	0.0001	0.0006	0.0005	0.0005	0.0026	0.0001	< 0.0001
L*	0.24	0.21	0.16	0.16	0.15	0.14	0.17	0.19	0.21	0.16	0.16	0.17	0.32	0.34	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.09	0.19	0.16	0.12	0.09	0.09	0.15	0.40	0.03	0.01
b*	< 0.01	0.01	0.01	0.01	< 0.01	0.12	0.45	0.23	0.25	0.15	0.15	0.14	0.38	0.00	0.01

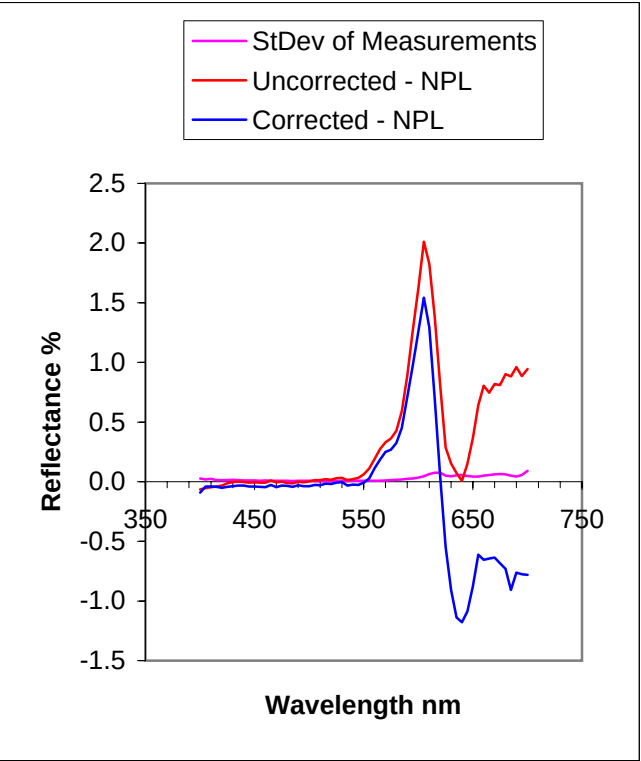
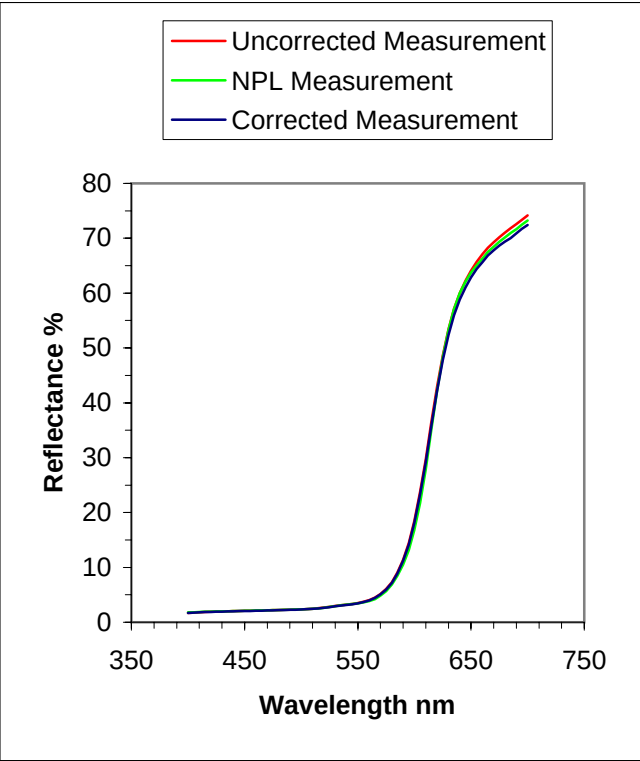
Colorimetry

			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	95.76	82.16	57.56	57.99	26.73	41.23	38.38	65.12	83.13	52.60	53.04	50.63	11.04	4.44	75.09
		a*	-0.27	-0.41	-0.14	-2.43	0.00	29.12	53.21	40.85	-4.53	-35.04	-34.01	-13.25	20.06	-1.54	-0.15
		b*	1.34	0.67	0.60	2.57	1.37	5.46	38.37	63.38	82.97	15.48	19.18	-33.02	-30.93	-0.63	-0.23
Average Measurement (Uncorrected)	B	L*	95.75	82.15	57.57	57.99	26.74	41.21	38.34	65.09	83.10	52.59	52.98	50.61	11.03	4.40	75.05
		a*	-0.27	-0.40	-0.15	-2.43	-0.01	29.06	53.17	40.82	-4.52	-35.04	-33.96	-13.24	20.07	-1.58	-0.16
		b*	1.36	0.66	0.63	2.55	1.39	5.40	38.37	63.37	82.97	15.47	19.15	-32.99	-30.94	-0.64	-0.20
Average Measurement (Corrected)	C	L*	95.12	81.60	57.16	57.57	26.50	40.87	38.01	64.61	82.53	52.21	52.60	50.25	10.88	4.33	74.53
		a*	-0.37	-0.49	-0.21	-2.48	-0.05	28.83	52.79	40.51	-4.62	-34.93	-33.86	-13.21	19.99	-1.57	-0.25
		b*	1.25	0.56	0.56	2.47	1.34	5.30	38.08	62.93	82.44	15.35	19.00	-32.86	-30.82	-0.64	-0.29
NPL Values	D	L*	95.45	81.63	57.13	57.60	26.62	40.68	37.71	64.80	82.75	52.42	53.06	50.28	10.75	3.93	74.78
		a*	-0.41	-0.38	-0.14	-2.48	-0.03	28.91	52.97	41.72	-4.27	-35.36	-35.03	-13.26	20.60	-1.61	-0.19
		b*	1.54	0.63	0.56	2.58	1.33	4.90	37.23	62.93	83.69	16.02	19.65	-32.97	-31.32	-0.50	-0.25
A to B		dE*	0.023	0.011	0.035	0.017	0.028	0.078	0.056	0.039	0.030	0.018	0.080	0.033	0.018	0.058	0.053
B to C		dE*	0.650	0.570	0.427	0.429	0.250	0.421	0.586	0.720	0.787	0.413	0.421	0.387	0.205	0.075	0.528
B to D		dE*	0.379	0.521	0.453	0.396	0.136	0.744	1.320	1.044	0.835	0.657	1.177	0.330	0.713	0.496	0.278
C to D		dE*	0.446	0.131	0.081	0.119	0.128	0.443	0.915	1.218	1.313	0.826	1.410	0.133	0.800	0.428	0.250
Corrected + Uncertainty	E	L*	95.76	82.19	57.71	58.12	27.24	41.46	38.61	65.17	83.13	52.76	53.15	50.80	12.40	6.03	75.11
		a*	-0.26	-0.38	-0.11	-2.38	0.09	28.93	53.03	40.66	-4.46	-34.72	-33.66	-12.98	21.30	-1.27	-0.14
		b*	1.47	0.78	0.76	2.67	1.66	5.57	39.41	63.50	82.68	15.57	19.24	-32.64	-29.69	-0.01	-0.08
Corrected - Uncertainty	F	L*	94.49	81.01	56.61	57.02	25.75	40.29	37.40	64.05	81.94	51.66	52.05	49.70	9.36	2.63	73.96
		a*	-0.49	-0.60	-0.31	-2.58	-0.19	28.74	52.55	40.36	-4.77	-35.14	-34.06	-13.43	18.69	-1.86	-0.35
		b*	1.02	0.35	0.36	2.27	1.03	5.02	36.74	62.35	82.19	15.13	18.76	-33.07	-31.94	-1.27	-0.50

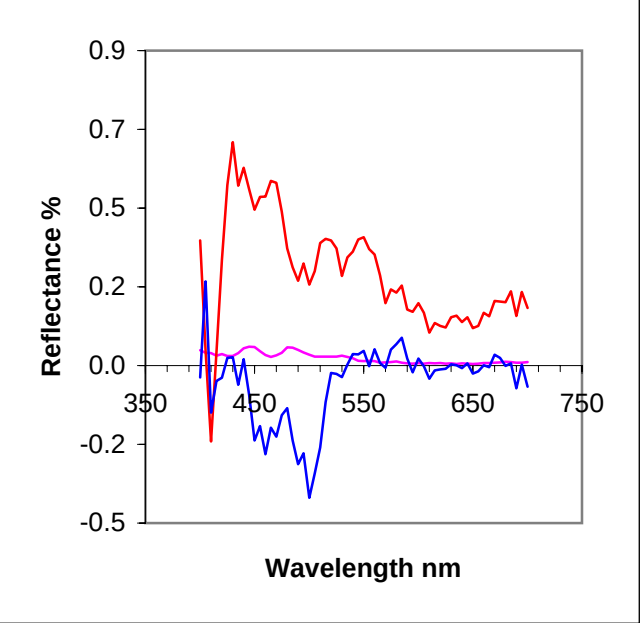
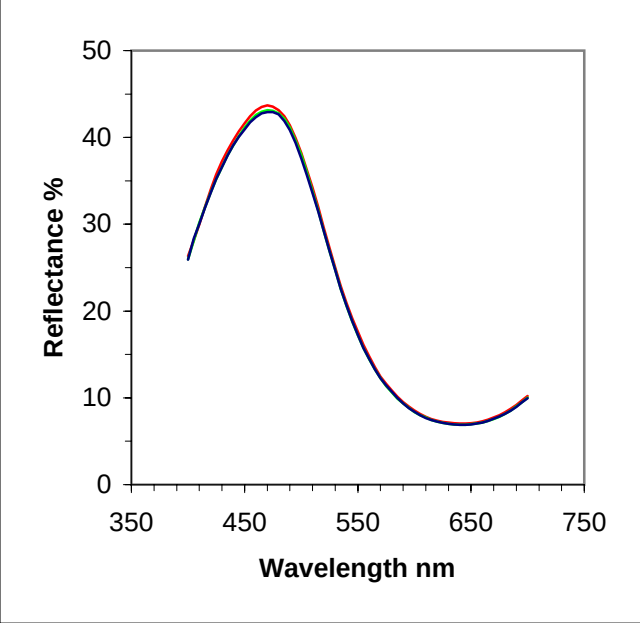




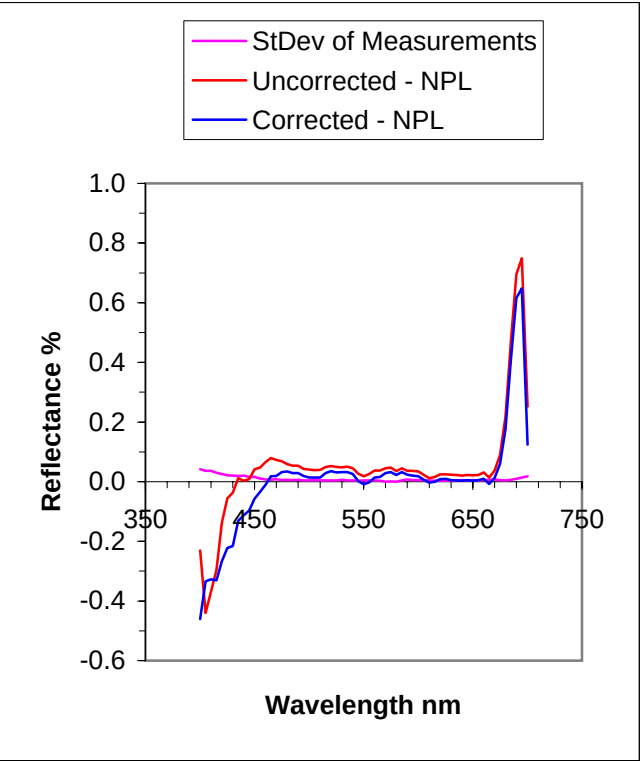
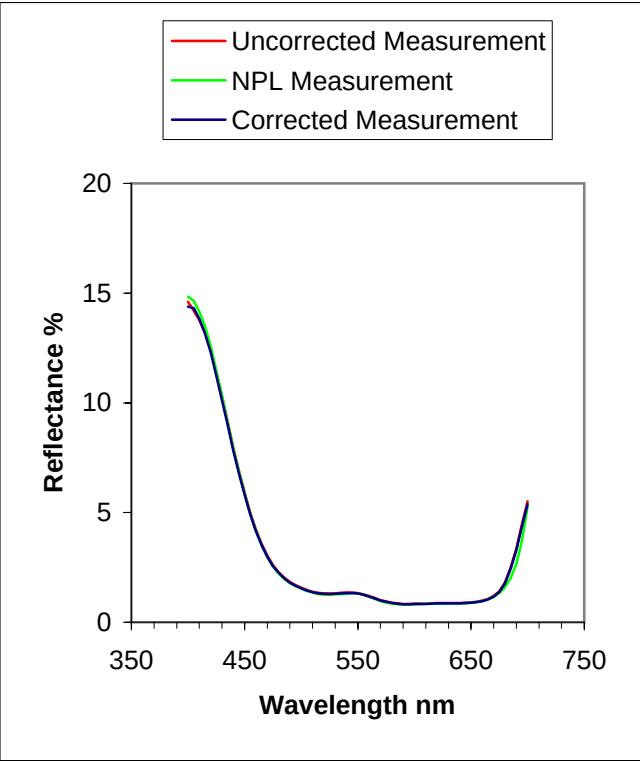




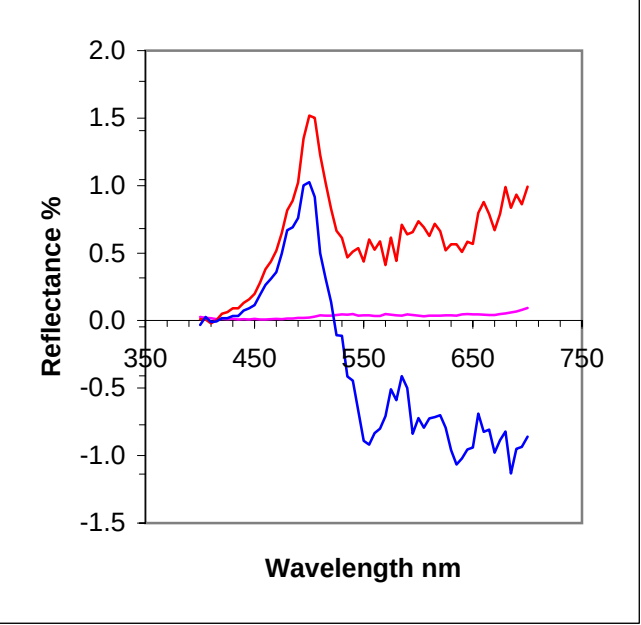
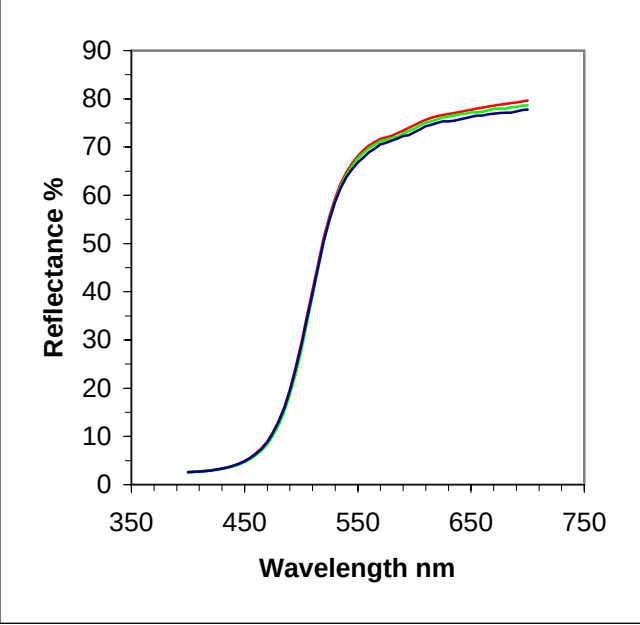
**Red
Gloss**



**Cyan
Gloss**



**Blue
Gloss**



**Yellow
Gloss**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 3

Aperture: Normal

Geometry: 45°/0°

Tiles: Matt

NPL Master Tiles: Colours CCM6

White WT45

Black BT10

Grey GT41

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0109	R%	+	0.6673	
450 nm	Uncert =	0.0121	R%	+	1.0322	
500 nm	Uncert =	0.0124	R%	+	1.0671	
550 nm	Uncert =	0.0122	R%	+	0.9674	
600 nm	Uncert =	0.0140	R%	+	0.8766	
650 nm	Uncert =	0.0151	R%	+	0.7953	
700 nm	Uncert =	0.0184	R%	+	0.4804	
<= 460 nm	Uncert =	0.012	R%	+	1.000	(k = 2)
>= 465 nm	Uncert =	0.018	R%	+	1.100	(k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	1.50	3.23
a*	0.15	1.36
b*	0.29	1.85

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0204	R%	+	0.9100	
450 nm	Uncert =	0.0142	R%	+	0.4892	
500 nm	Uncert =	0.0135	R%	+	0.4062	
550 nm	Uncert =	0.0160	R%	+	0.4760	
600 nm	Uncert =	0.0138	R%	+	0.5221	
650 nm	Uncert =	0.0126	R%	+	0.4769	
700 nm	Uncert =	0.0118	R%	+	0.6254	
<= 460 nm	Uncert =	0.02	R%	+	0.900	(k = 2)
>= 460 nm	Uncert =	0.015	R%	+	0.700	(k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	1.05	2.09
a*	0.19	0.65
b*	0.49	1.33

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	2.73	2.27	1.65	1.66	1.28	1.40	1.39	1.81	2.31	1.58	1.58	1.53	1.22	1.21	2.02
x	0.0003	0.0003	0.0004	0.0004	0.0013	0.0037	0.0096	0.0054	0.0026	0.0019	0.0017	0.0037	0.0076	0.0036	0.0004
y	0.0006	0.0007	0.0008	0.0006	0.0017	0.0021	0.0011	0.0014	0.0029	0.0022	0.0027	0.0035	0.0131	0.0042	0.0007
L*	1.14	1.18	1.43	1.42	2.36	1.83	1.86	1.32	1.18	1.50	1.50	1.57	3.09	3.23	1.23
a*	0.15	0.14	0.14	0.10	0.12	0.94	1.36	0.46	0.15	0.63	0.65	0.08	1.11	0.12	0.14
b*	0.29	0.28	0.27	0.23	0.38	0.17	0.60	1.11	1.20	0.04	0.12	0.76	1.85	0.70	0.28

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

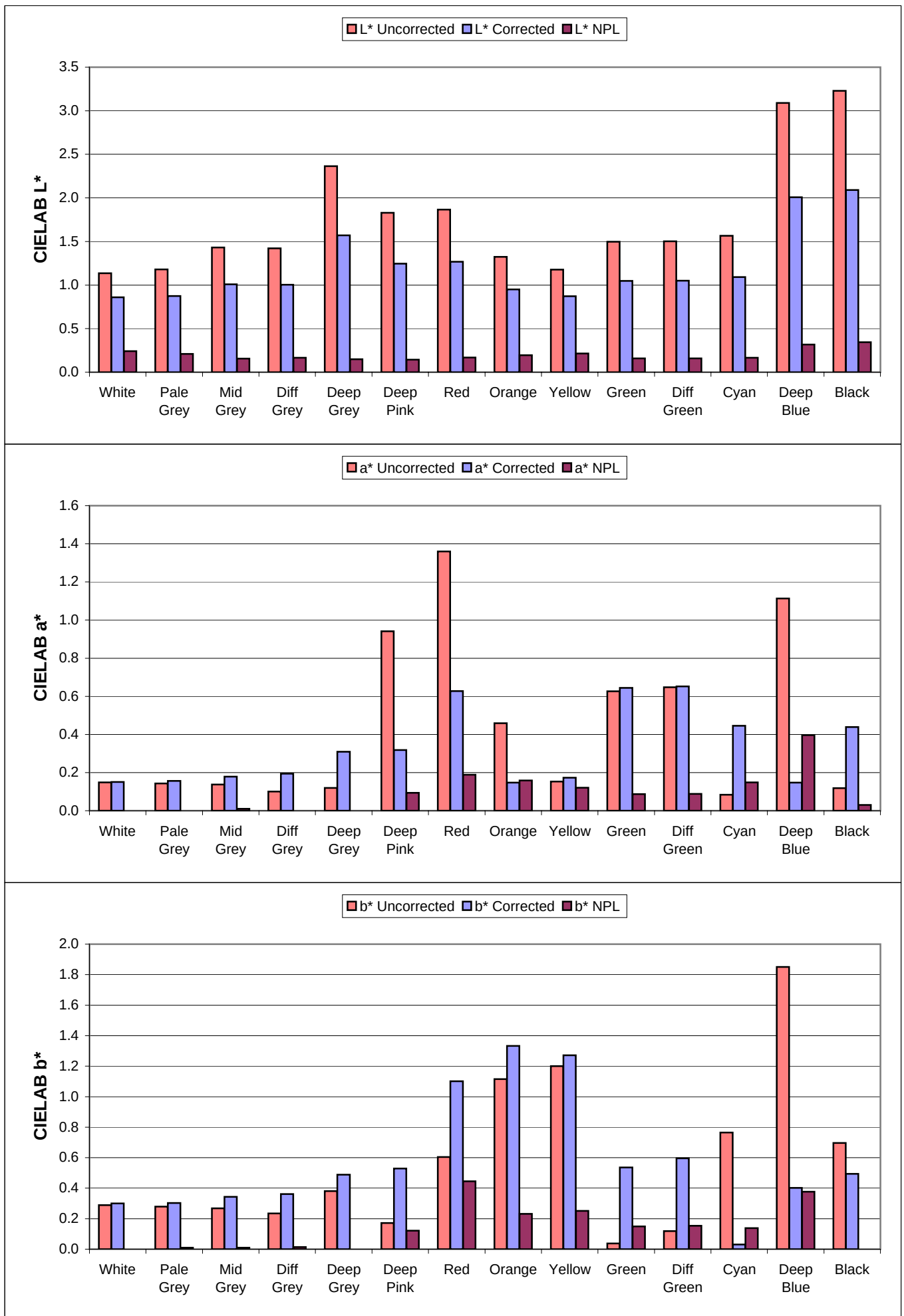
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	2.05	1.67	1.15	1.16	0.85	0.95	0.94	1.29	1.70	1.10	1.10	1.06	0.80	0.79	1.47
x	0.0003	0.0004	0.0005	0.0005	0.0008	0.0038	0.0080	0.0045	0.0022	0.0006	0.0005	0.0020	0.0033	0.0001	0.0004
y	0.0007	0.0008	0.0011	0.0013	0.0023	0.0007	0.0013	0.0021	0.0028	0.0035	0.0039	0.0007	0.0048	0.0026	0.0008
L*	0.86	0.88	1.01	1.00	1.57	1.25	1.27	0.95	0.87	1.05	1.05	1.09	2.01	2.09	0.90
a*	0.15	0.16	0.18	0.19	0.31	0.32	0.63	0.15	0.17	0.64	0.65	0.45	0.15	0.44	0.16
b*	0.30	0.30	0.34	0.36	0.49	0.53	1.10	1.33	1.27	0.54	0.60	0.03	0.40	0.49	0.31

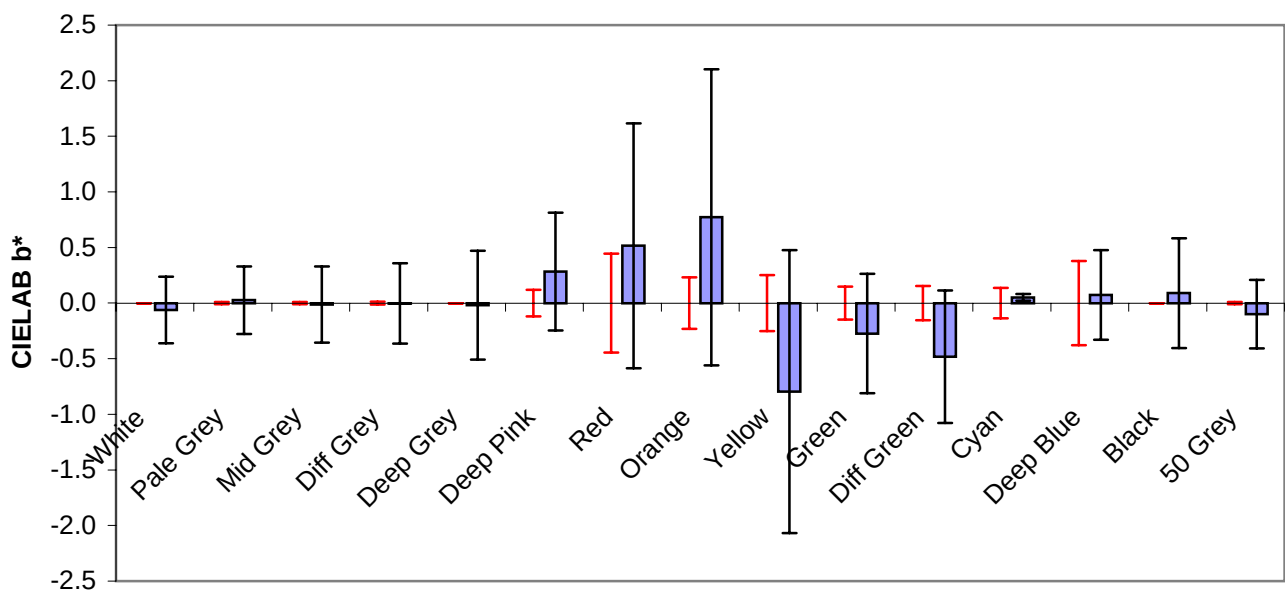
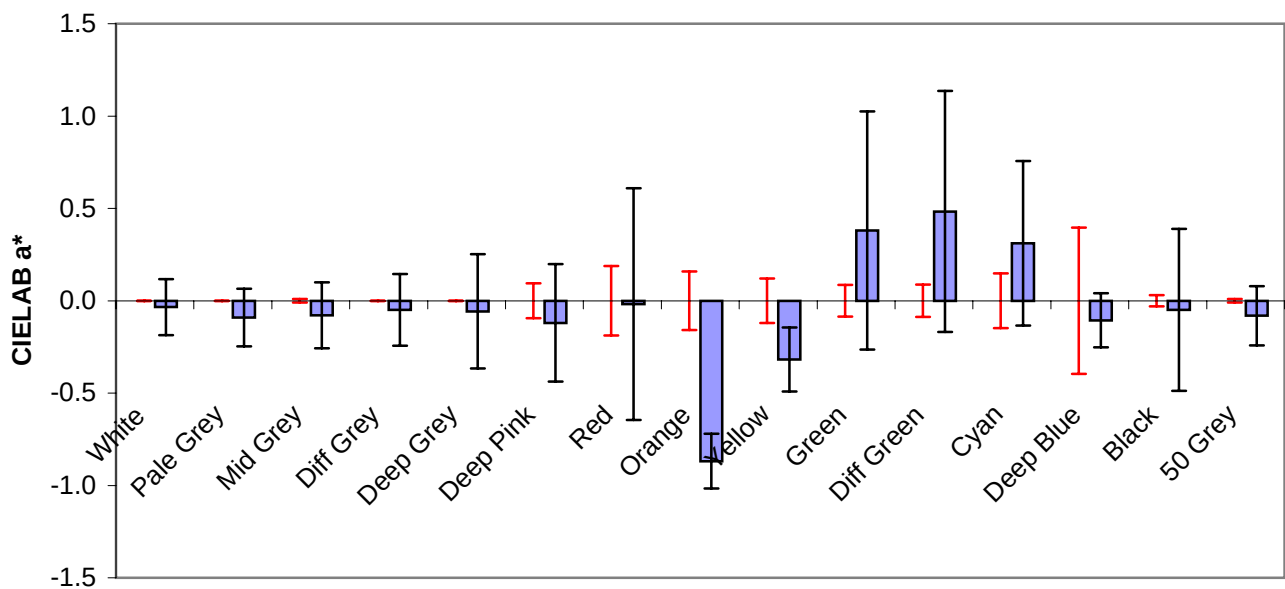
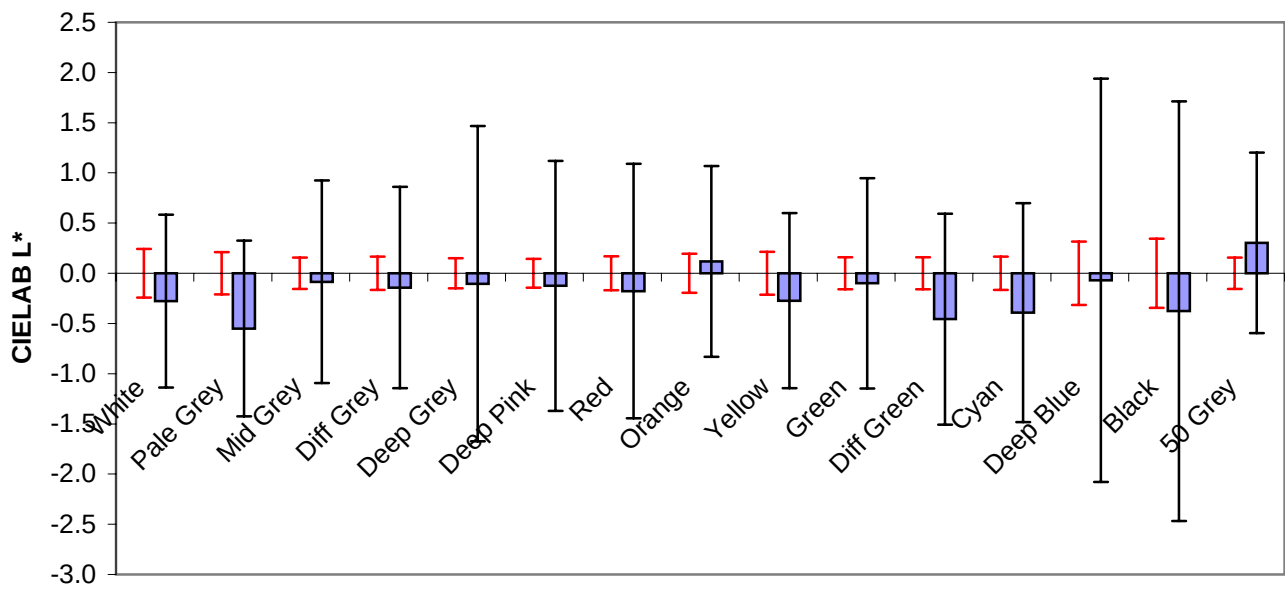
NPL Lambda Uncertainty

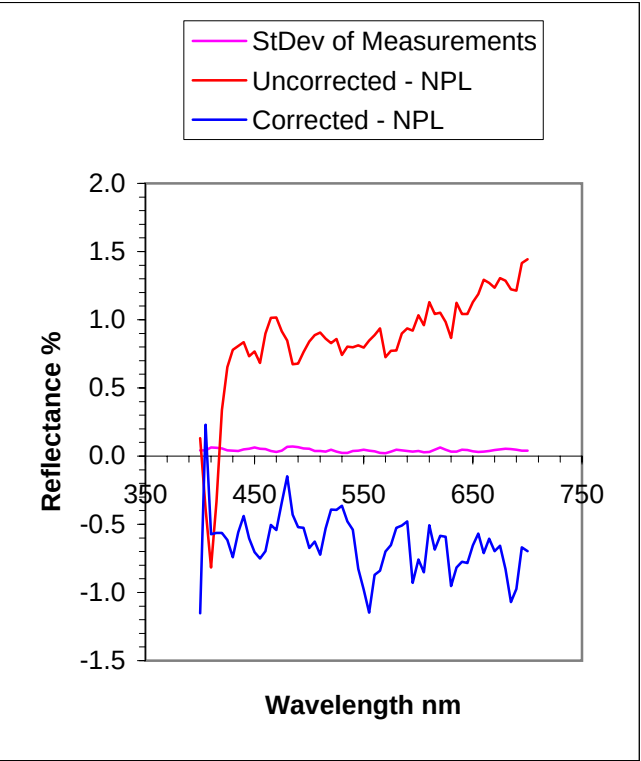
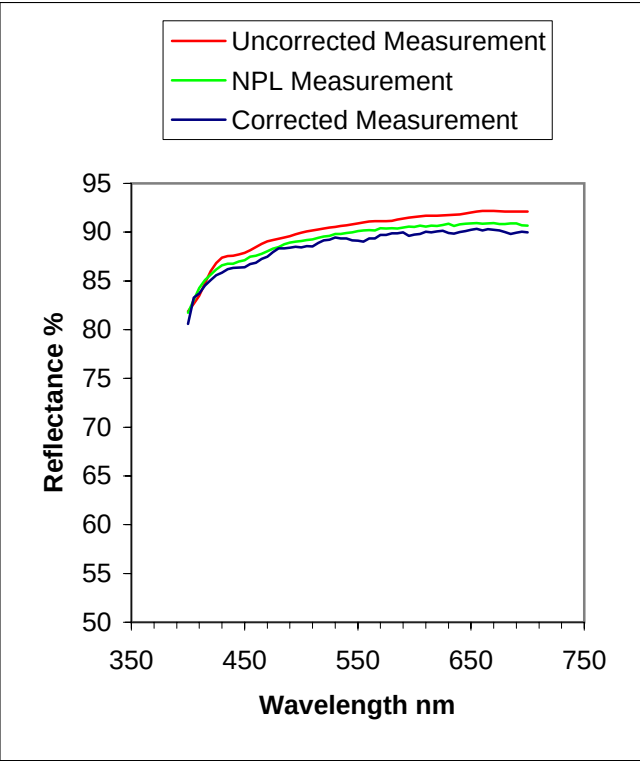
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.57	0.39	0.16	0.16	0.05	0.08	0.08	0.24	0.40	0.14	0.14	0.14	0.04	0.04	0.16
x	0.0002	0.0000	0.0000	0.0000	0.0000	0.0006	0.0016	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	0.0000
y	0.0001	0.0000	0.0000	0.0000	0.0000	0.0003	0.0001	0.0004	0.0001	0.0006	0.0005	0.0005	0.0026	0.0001	0.0000
L*	0.24	0.21	0.16	0.16	0.15	0.14	0.17	0.19	0.21	0.16	0.16	0.17	0.32	0.34	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.09	0.19	0.16	0.12	0.09	0.09	0.15	0.40	0.03	0.01
b*	< 0.01	0.01	0.01	0.01	< 0.01	0.12	0.45	0.23	0.25	0.15	0.15	0.14	0.38	0.00	0.01

Colorimetry

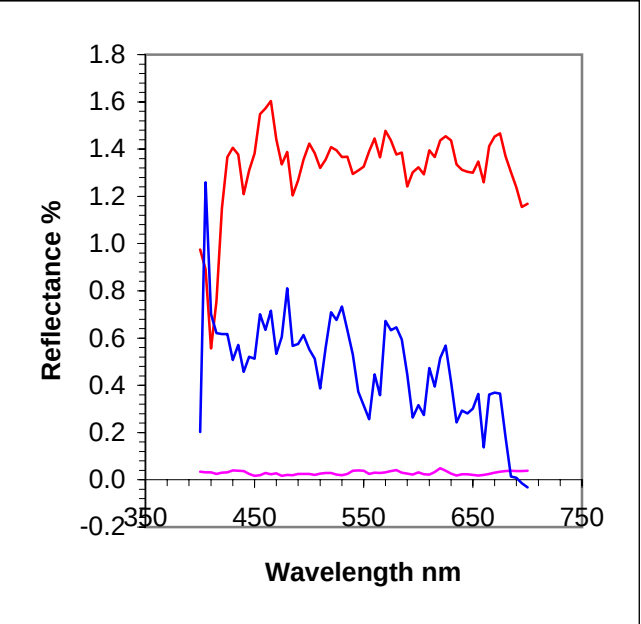
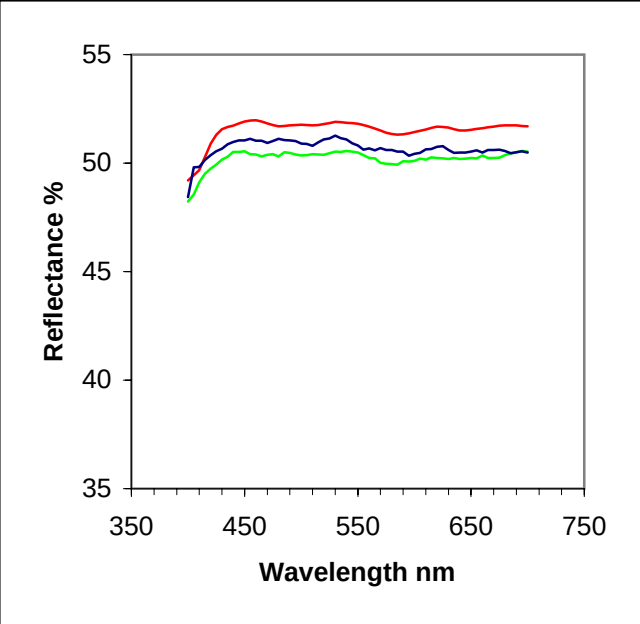
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	96.38	84.67	62.08	62.58	38.29	48.02	47.24	69.14	85.71	58.88	58.72	56.00	30.82	29.66	77.06
		a*	-0.21	-0.27	-0.21	-1.95	-0.80	23.14	37.17	36.68	-4.43	-27.92	-28.17	-10.71	7.27	-0.82	-0.21
		b*	1.92	0.49	0.30	1.96	-0.60	3.42	16.29	47.24	72.36	11.02	13.44	-28.17	-16.65	-2.18	-0.07
Average Measurement (Uncorrected)	B	L*	96.36	84.63	62.08	62.58	38.32	48.03	47.20	68.97	85.68	58.87	58.70	55.98	30.79	29.73	77.08
		a*	-0.23	-0.30	-0.21	-1.97	-0.80	23.12	37.12	36.68	-4.42	-27.90	-28.17	-10.70	7.26	-0.81	-0.22
		b*	1.94	0.53	0.31	1.96	-0.58	3.42	16.28	47.16	72.35	11.02	13.45	-28.11	-16.63	-2.19	-0.06
Average Measurement (Corrected)	C	L*	95.72	84.06	61.64	62.14	38.01	47.66	46.83	68.47	85.09	58.46	58.29	55.59	30.52	29.47	76.55
		a*	-0.33	-0.39	-0.28	-2.03	-0.84	22.92	36.81	36.39	-4.52	-27.83	-28.10	-10.69	7.20	-0.85	-0.30
		b*	1.83	0.43	0.23	1.88	-0.63	3.32	16.10	46.81	71.86	10.91	13.33	-28.01	-16.60	-2.22	-0.14
NPL Values	D	L*	96.00	84.61	61.72	62.28	38.11	47.79	47.01	68.35	85.36	58.56	58.75	55.98	30.59	29.85	76.25
		a*	-0.30	-0.30	-0.20	-1.98	-0.79	23.04	36.83	37.26	-4.21	-28.21	-28.59	-11.00	7.31	-0.80	-0.22
		b*	1.89	0.41	0.24	1.88	-0.61	3.04	15.59	46.04	72.66	11.18	13.81	-28.06	-16.68	-2.31	-0.04
A to B		dE*	0.036	0.068	0.012	0.016	0.029	0.022	0.069	0.193	0.038	0.019	0.019	0.063	0.046	0.066	0.031
B to C		dE*	0.654	0.584	0.453	0.456	0.313	0.433	0.512	0.678	0.763	0.435	0.438	0.407	0.270	0.262	0.539
B to D		dE*	0.370	0.127	0.362	0.313	0.205	0.462	0.771	1.412	0.492	0.471	0.549	0.307	0.203	0.171	0.828
C to D		dE*	0.285	0.558	0.117	0.150	0.120	0.333	0.546	1.168	0.899	0.479	0.822	0.503	0.147	0.391	0.329
Corrected + Uncertainty	E	L*	96.58	84.94	62.65	63.14	39.58	48.91	48.10	69.42	85.96	59.50	59.34	56.68	32.53	31.56	77.45
		a*	-0.18	-0.24	-0.10	-1.83	-0.53	23.24	37.44	36.54	-4.35	-27.19	-27.45	-10.25	7.35	-0.41	-0.14
		b*	2.12	0.74	0.58	2.24	-0.14	3.85	17.20	48.14	73.14	11.44	13.92	-27.98	-16.20	-1.72	0.16
Corrected - Uncertainty	F	L*	94.86	83.19	60.63	61.13	36.44	46.42	45.56	67.52	84.22	57.41	57.24	54.50	28.51	27.38	75.65
		a*	-0.48	-0.55	-0.46	-2.22	-1.15	22.60	36.19	36.25	-4.70	-28.48	-28.76	-11.14	7.06	-1.29	-0.46
		b*	1.53	0.13	-0.11	1.52	-1.12	2.79	15.00	45.47	70.59	10.37	12.73	-28.04	-17.00	-2.71	-0.45



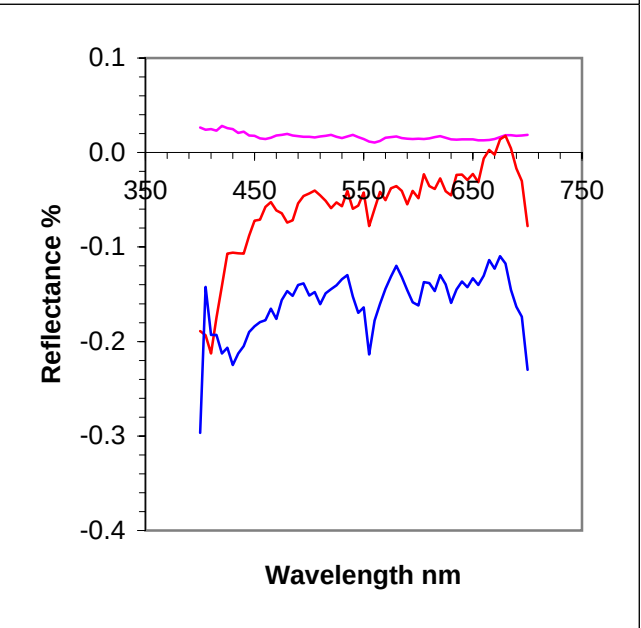
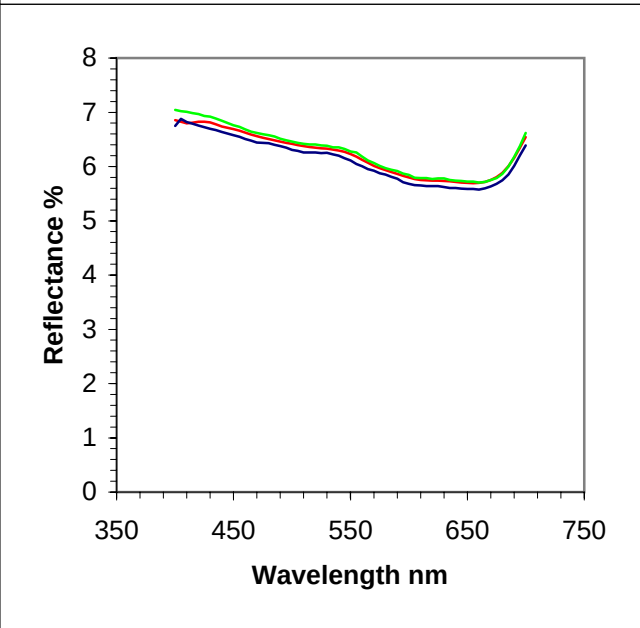




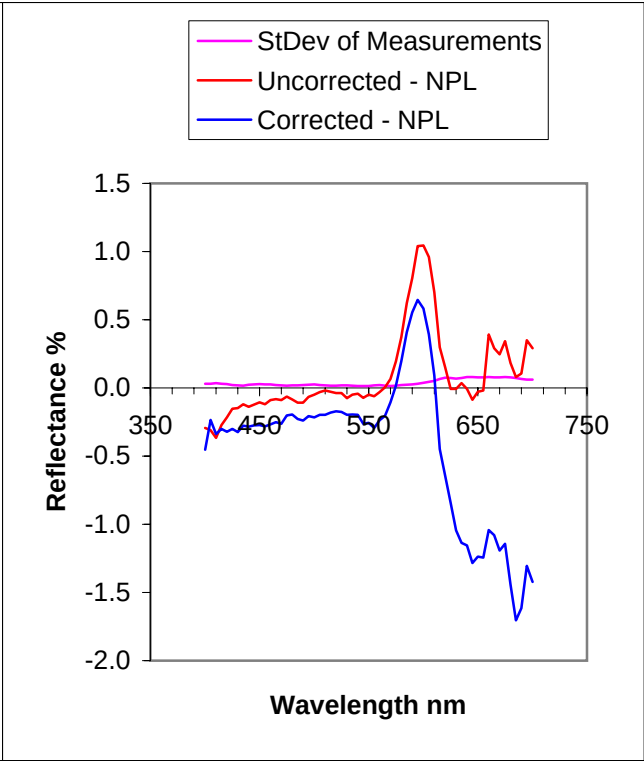
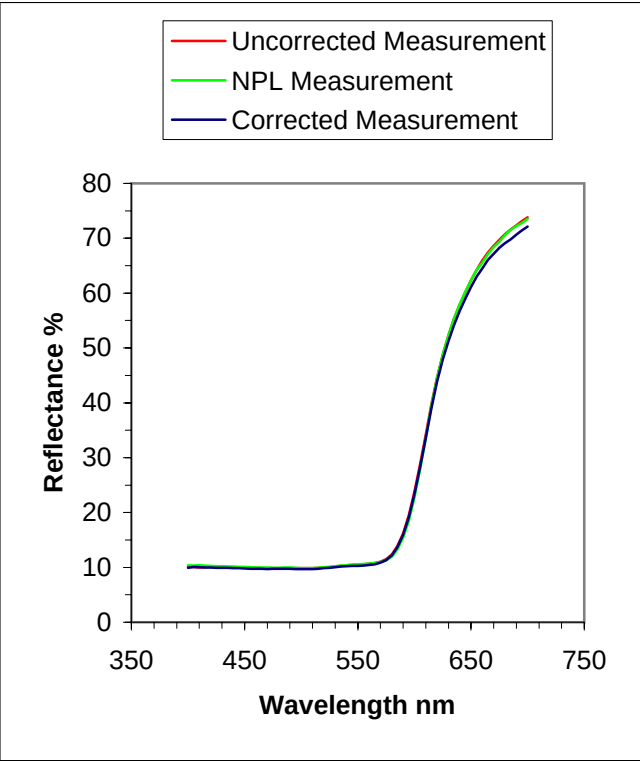
**White
Matt**



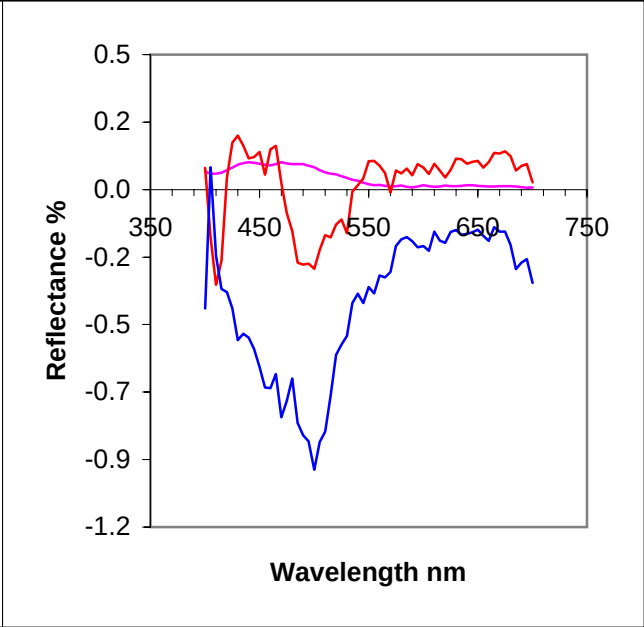
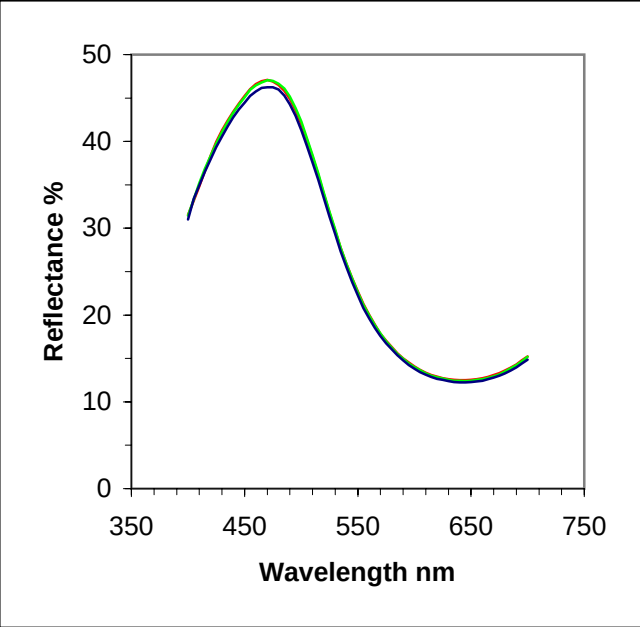
**50 Grey
Matt**



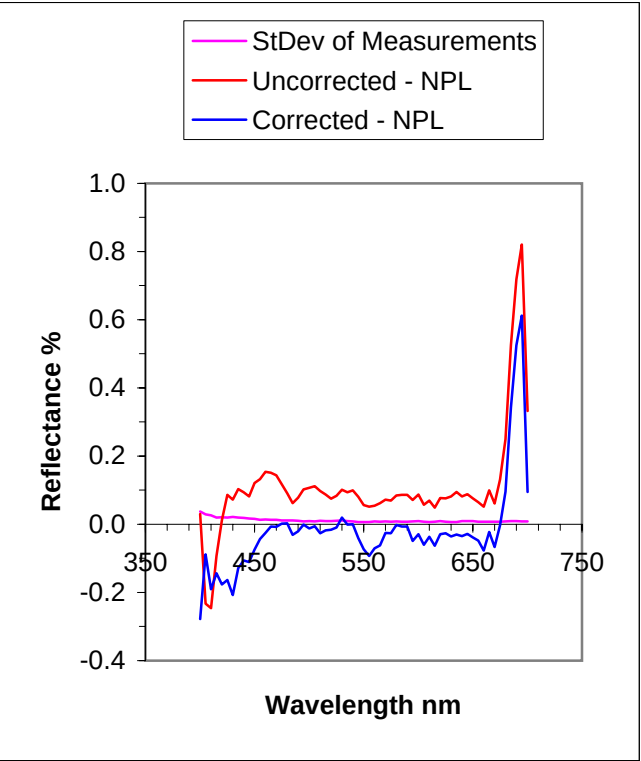
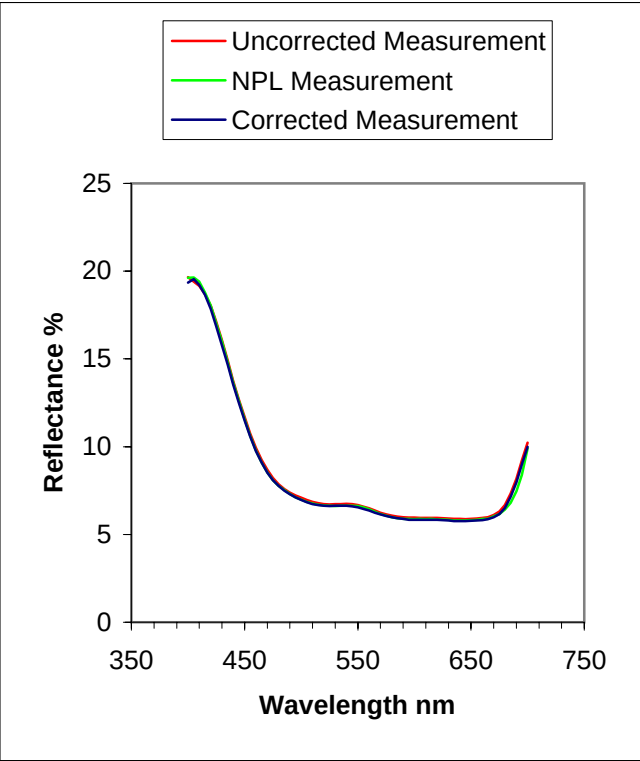
**Black
Matt**



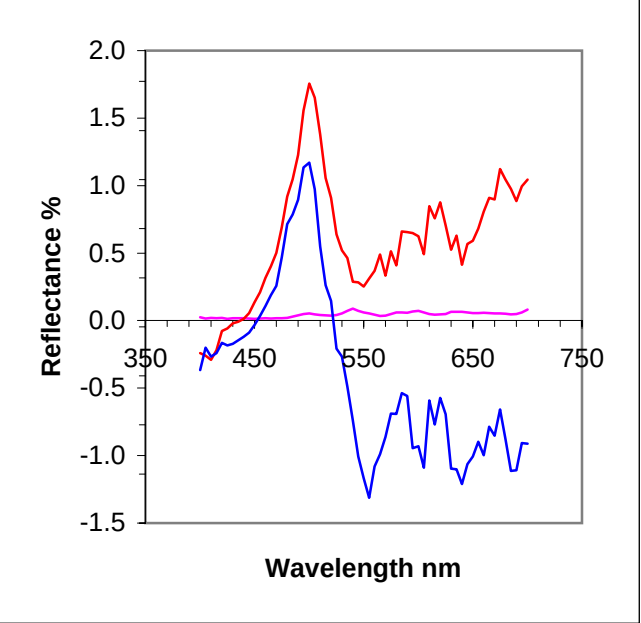
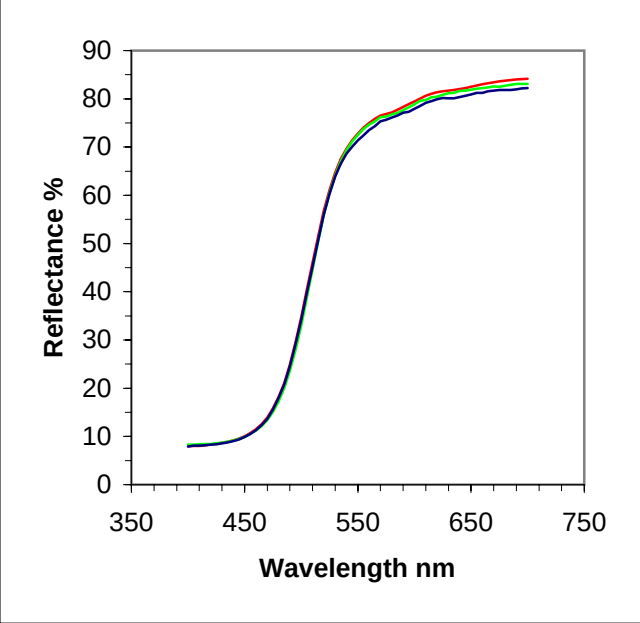
Red
Matt



Cyan
Matt



**Blue
Matt**



**Yellow
Matt**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 4

Aperture: Normal

Geometry: 45°/0°

Tiles: Gloss

NPL Master Tiles: Colours CCS3

White WT56

Black BT03

Grey GT51

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0247	R%	+	0.6251
450 nm	Uncert =	0.0177	R%	+	0.7344
500 nm	Uncert =	0.0152	R%	+	0.7055
550 nm	Uncert =	0.0173	R%	+	0.6997
600 nm	Uncert =	0.0140	R%	+	0.5699
650 nm	Uncert =	0.0138	R%	+	0.7114
700 nm	Uncert =	0.0092	R%	+	0.6721

<= 460 nm Uncert = **0.025** R% + **0.750** (k = 2)

>= 465 nm Uncert = **0.018** R% + **0.700** (k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	1.22	6.44
a*	0.24	6.25
b*	0.58	5.61

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0158	R%	+	0.6818
450 nm	Uncert =	0.0165	R%	+	0.7413
500 nm	Uncert =	0.0164	R%	+	0.7005
550 nm	Uncert =	0.0163	R%	+	0.7032
600 nm	Uncert =	0.0119	R%	+	0.5834
650 nm	Uncert =	0.0127	R%	+	0.7138
700 nm	Uncert =	0.0112	R%	+	0.6641

<= 460 nm Uncert = **0.017** R% + **0.750** (k = 2)

>= 460 nm Uncert = **0.017** R% + **0.700** (k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	1.19	6.43
a*	0.26	6.48
b*	0.38	5.80

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	2.29	1.78	1.16	1.17	0.79	0.92	0.89	1.30	1.77	1.06	1.07	1.04	0.73	0.71	1.56
x	0.0005	0.0005	0.0007	0.0007	0.0024	0.0068	0.0214	0.0062	0.0026	0.0012	0.0008	0.0030	0.0273	0.0850	0.0005
y	0.0009	0.0010	0.0011	0.0014	0.0032	< 0.0001	0.0015	0.0024	0.0031	0.0055	0.0060	0.0014	0.0493	0.0516	0.0010
L*	0.98	0.99	1.15	1.14	2.38	1.51	1.61	1.07	0.98	1.23	1.22	1.27	5.69	6.44	1.01
a*	0.18	0.16	0.14	0.17	0.13	0.73	1.48	0.24	0.16	0.90	0.85	0.57	6.25	0.54	0.16
b*	0.41	0.38	0.34	0.36	0.53	0.58	4.48	2.31	1.57	0.65	0.74	0.05	5.61	0.73	0.36

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

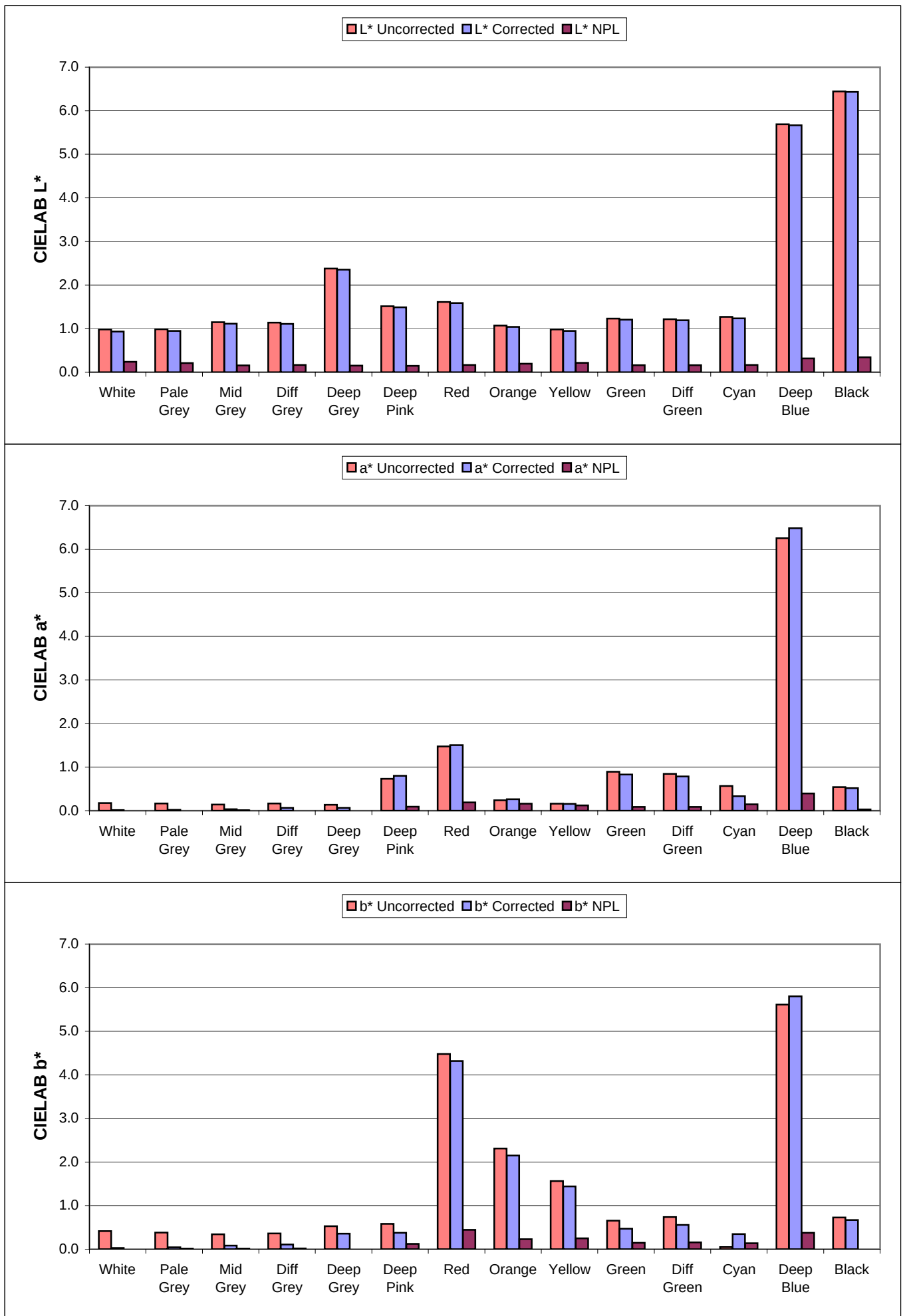
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	2.19	1.71	1.13	1.13	0.79	0.90	0.88	1.27	1.71	1.04	1.05	1.01	0.73	0.71	1.50
x	< 0.0001	< 0.0001	0.0002	0.0002	0.0018	0.0062	0.0210	0.0060	0.0025	0.0015	0.0011	0.0032	0.0274	0.0910	< 0.0001
y	< 0.0001	0.0001	0.0003	0.0005	0.0022	0.0007	0.0013	0.0022	0.0029	0.0047	0.0051	0.0024	0.0496	0.0462	0.0001
L*	0.93	0.95	1.12	1.11	2.36	1.49	1.59	1.04	0.95	1.21	1.19	1.24	5.67	6.43	0.97
a*	0.01	0.02	0.03	0.06	0.06	0.80	1.50	0.26	0.16	0.83	0.79	0.33	6.48	0.52	0.02
b*	0.03	0.04	0.08	0.11	0.36	0.38	4.32	2.15	1.44	0.47	0.56	0.35	5.80	0.67	0.05

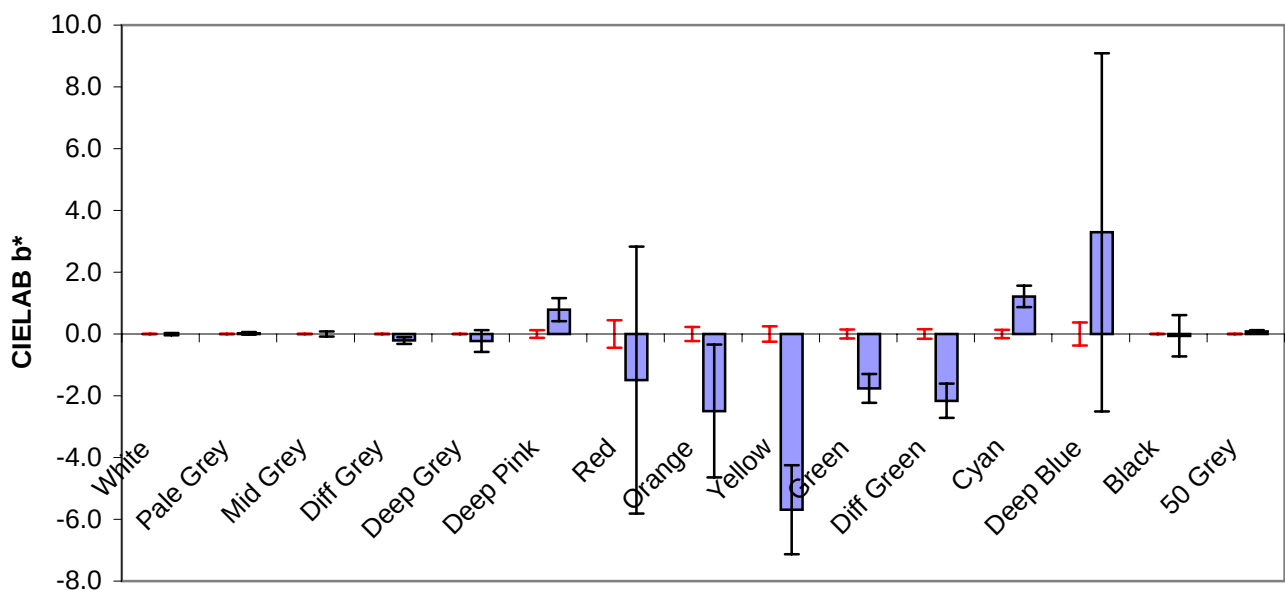
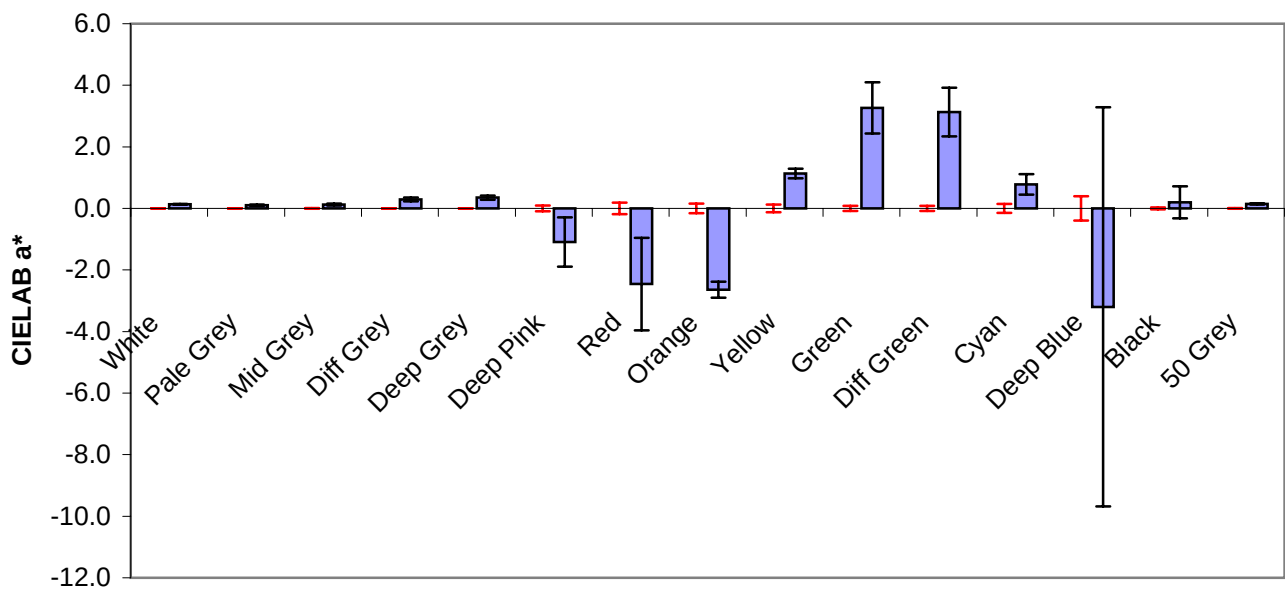
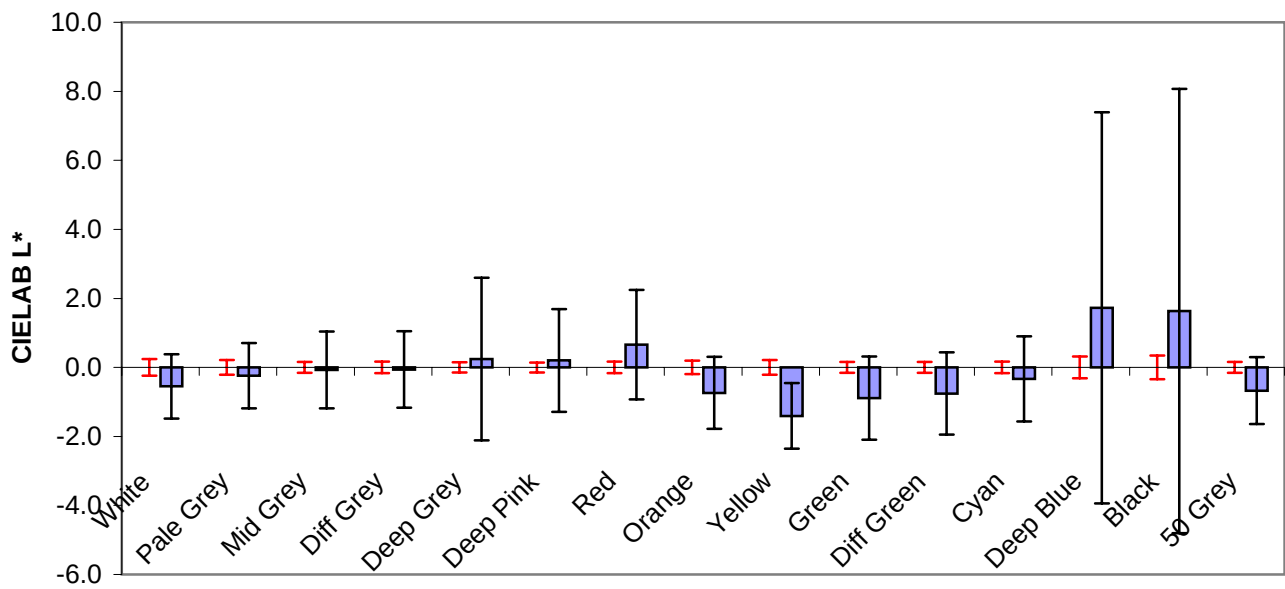
NPL Lambda Uncertainty

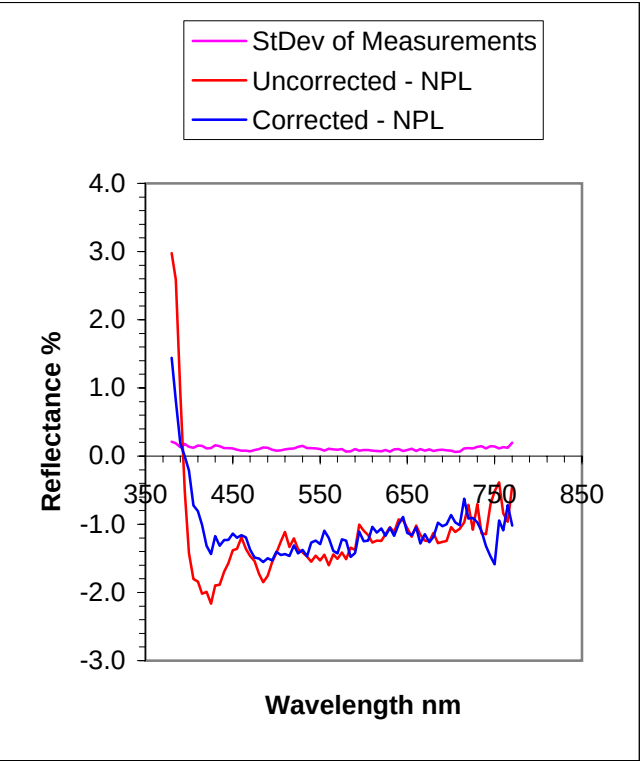
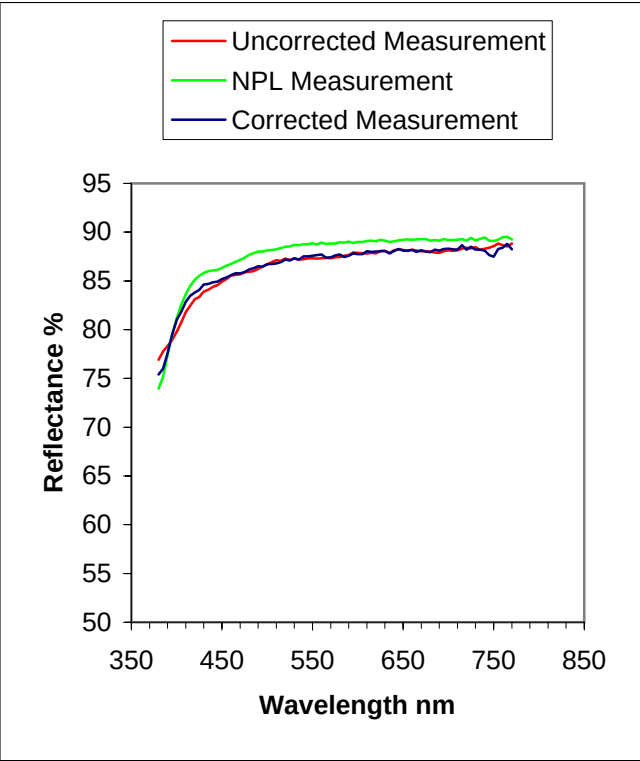
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.57	0.39	0.16	0.16	0.05	0.08	0.08	0.24	0.40	0.14	0.14	0.14	0.04	0.04	0.16
x	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0006	0.0016	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	< 0.0001
y	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0001	0.0004	0.0001	0.0006	0.0005	0.0005	0.0026	0.0001	< 0.0001
L*	0.24	0.21	0.16	0.16	0.15	0.14	0.17	0.19	0.21	0.16	0.16	0.17	0.32	0.34	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.09	0.19	0.16	0.12	0.09	0.09	0.15	0.40	0.03	0.01
b*	< 0.01	0.01	0.01	0.01	< 0.01	0.12	0.45	0.23	0.25	0.15	0.15	0.14	0.38	0.00	0.01

Colorimetry

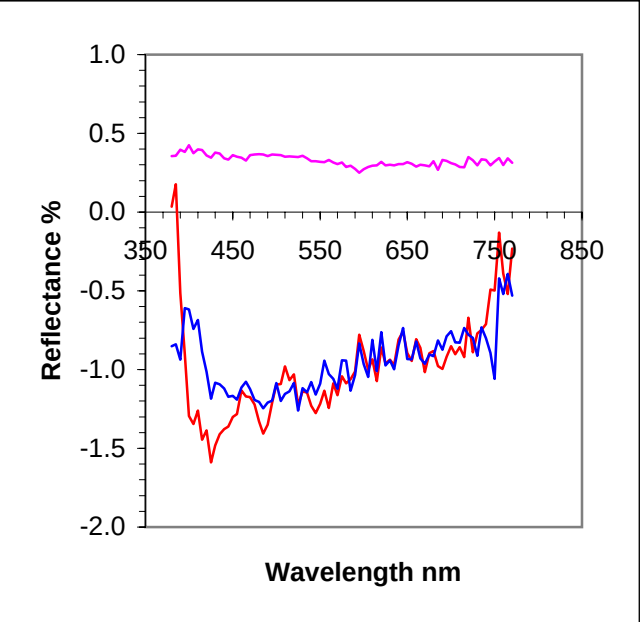
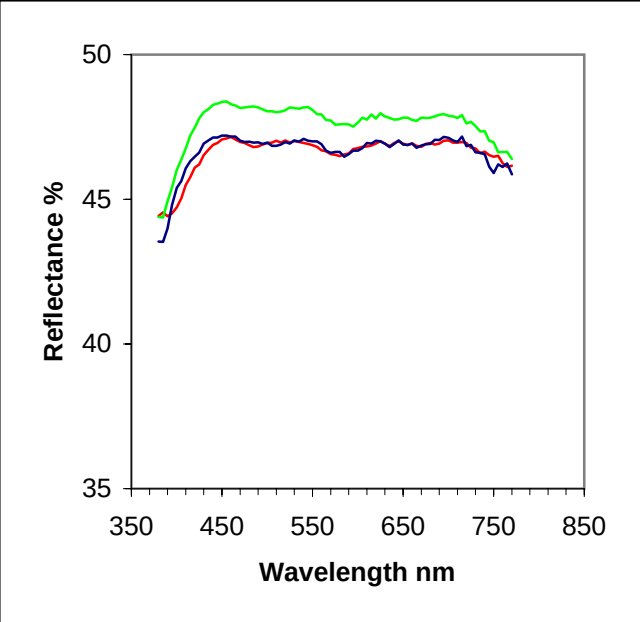
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	94.84	81.33	57.28	57.59	26.52	40.65	38.27	64.34	81.63	51.72	52.31	50.03	12.42	5.46	74.31
		a*	-0.28	-0.38	-0.10	-2.26	0.21	27.61	50.18	39.20	-3.22	-32.41	-31.68	-12.58	17.75	-1.11	-0.13
		b*	1.75	0.86	0.72	2.46	1.24	5.63	35.53	60.86	78.51	14.68	17.80	-31.51	-28.08	-1.02	-0.04
Average Measurement (Uncorrected)	B	L*	94.87	81.36	57.03	57.51	26.86	40.89	38.40	64.05	81.31	51.51	52.28	49.93	12.50	5.56	74.07
		a*	-0.35	-0.35	-0.06	-2.24	0.34	27.89	50.59	39.08	-3.14	-32.14	-31.93	-12.61	17.57	-1.38	-0.11
		b*	1.72	0.81	0.68	2.49	1.17	5.80	35.86	60.51	78.05	14.35	17.57	-31.58	-27.94	-0.52	-0.03
Average Measurement (Corrected)	C	L*	94.91	81.39	57.05	57.54	26.87	40.90	38.40	64.07	81.35	51.52	52.30	49.95	12.51	5.57	74.10
		a*	-0.28	-0.29	-0.02	-2.19	0.37	27.91	50.59	39.06	-3.17	-32.10	-31.90	-12.48	17.68	-1.37	-0.05
		b*	1.55	0.66	0.57	2.38	1.11	5.70	35.81	60.46	78.04	14.29	17.52	-31.72	-28.05	-0.54	-0.17
NPL Values	D	L*	95.45	81.63	57.13	57.60	26.63	40.70	37.74	64.81	82.75	52.42	53.06	50.28	10.79	3.93	74.78
		a*	-0.42	-0.39	-0.14	-2.49	0.02	29.00	53.04	41.70	-4.30	-35.36	-35.03	-13.26	20.88	-1.57	-0.19
		b*	1.56	0.64	0.57	2.60	1.34	4.91	37.30	62.95	83.73	16.05	19.68	-32.93	-31.34	-0.49	-0.24
A to B		dE*	0.081	0.063	0.251	0.085	0.368	0.400	0.540	0.472	0.564	0.475	0.339	0.131	0.238	0.581	0.234
B to C		dE*	0.182	0.161	0.121	0.115	0.070	0.101	0.051	0.061	0.047	0.075	0.069	0.194	0.158	0.029	0.151
B to D		dE*	0.607	0.323	0.166	0.282	0.430	1.433	2.920	3.660	5.974	3.761	3.823	1.539	5.047	1.640	0.738
C to D		dE*	0.564	0.264	0.146	0.365	0.484	1.358	2.948	3.708	5.969	3.818	3.878	1.484	4.903	1.647	0.692
Corrected + Uncertainty	E	L*	95.84	82.34	58.17	58.65	29.23	42.39	39.99	65.11	82.29	52.73	53.49	51.18	18.18	12.00	75.07
		a*	-0.27	-0.27	0.02	-2.13	0.43	28.71	52.09	39.32	-3.02	-31.27	-31.11	-12.14	24.16	-0.85	-0.03
		b*	1.58	0.70	0.65	2.49	1.46	6.07	40.13	62.61	79.48	14.76	18.07	-31.37	-22.25	0.13	-0.12
Corrected - Uncertainty	F	L*	93.97	80.45	55.94	56.43	24.52	39.41	36.81	63.03	80.40	50.32	51.11	48.71	6.85	-0.87	73.13
		a*	-0.30	-0.31	-0.05	-2.26	0.30	27.11	49.08	38.79	-3.33	-32.93	-32.69	-12.81	11.20	-1.89	-0.07
		b*	1.52	0.62	0.49	2.28	0.75	5.32	31.49	58.31	76.60	13.82	16.96	-32.07	-33.85	-1.21	-0.21



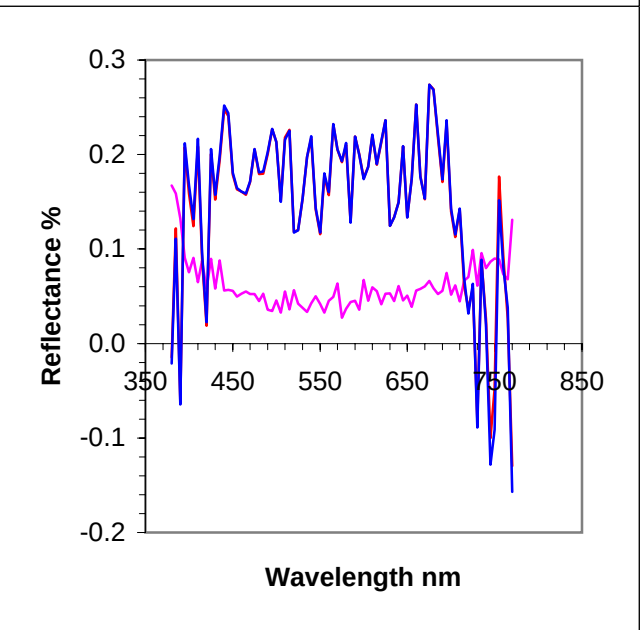
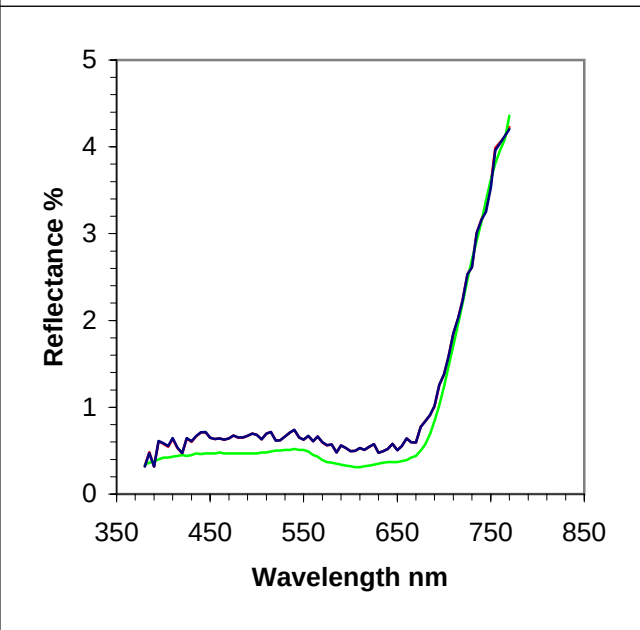




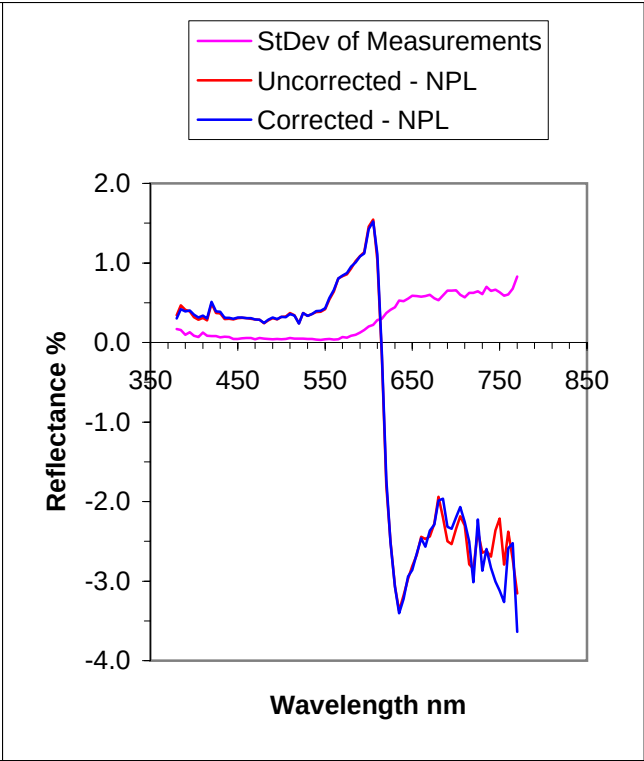
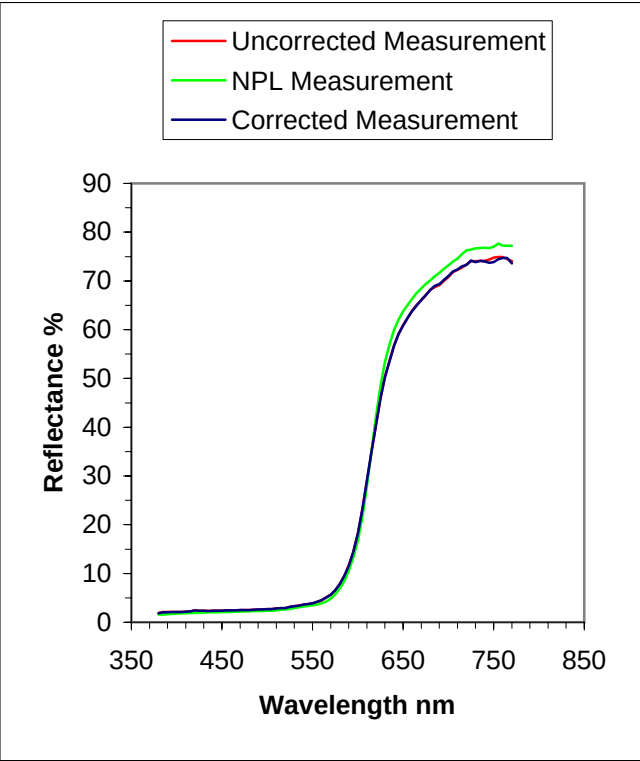
**White
Gloss**



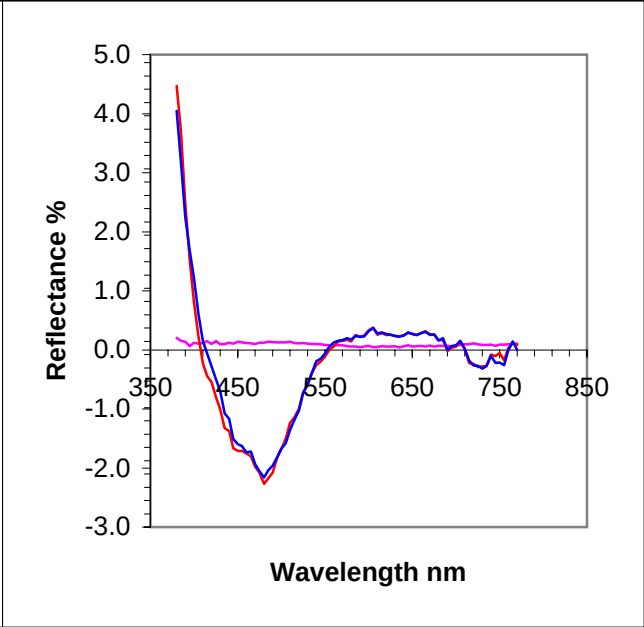
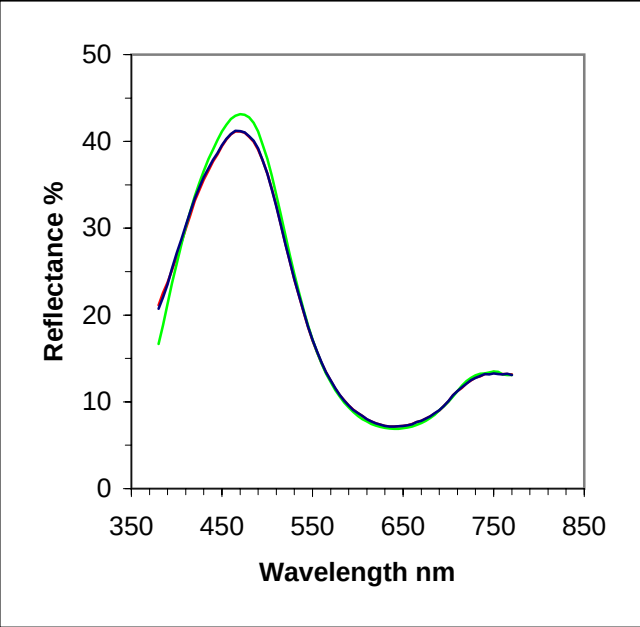
**50 Grey
Gloss**



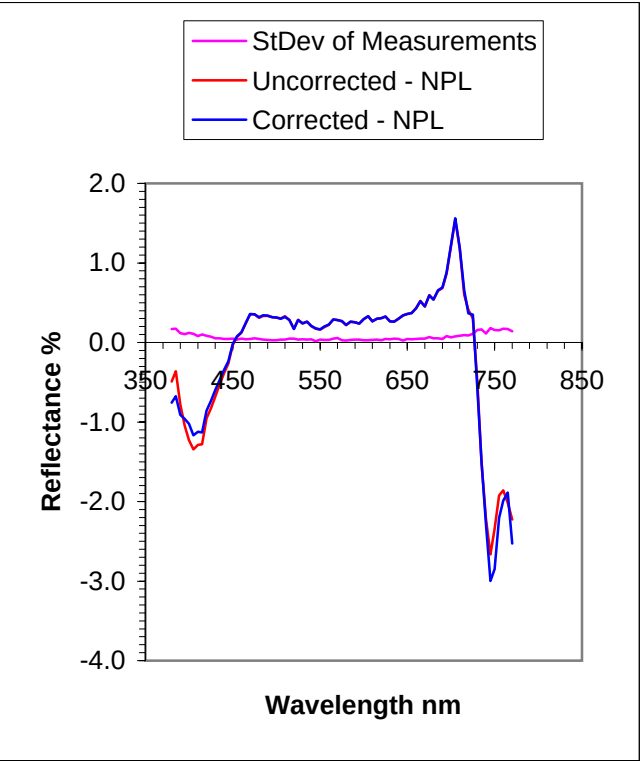
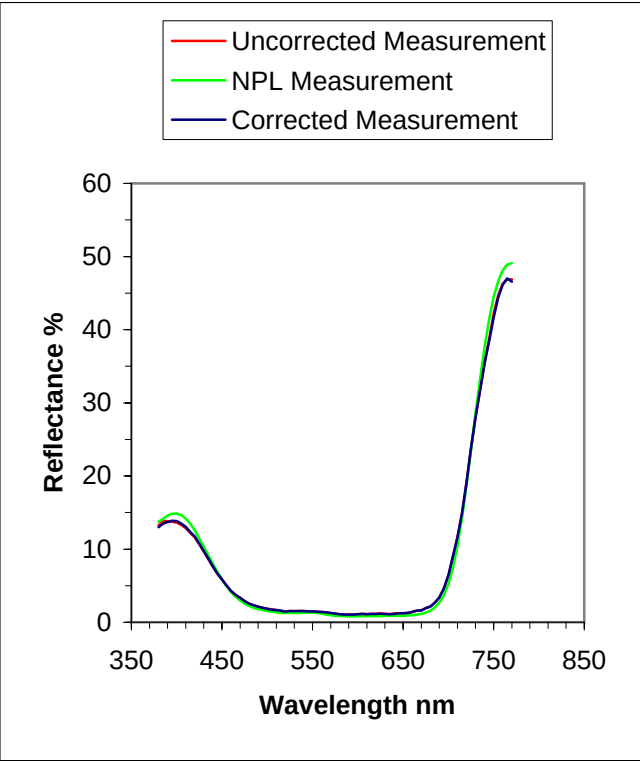
**Black
Gloss**



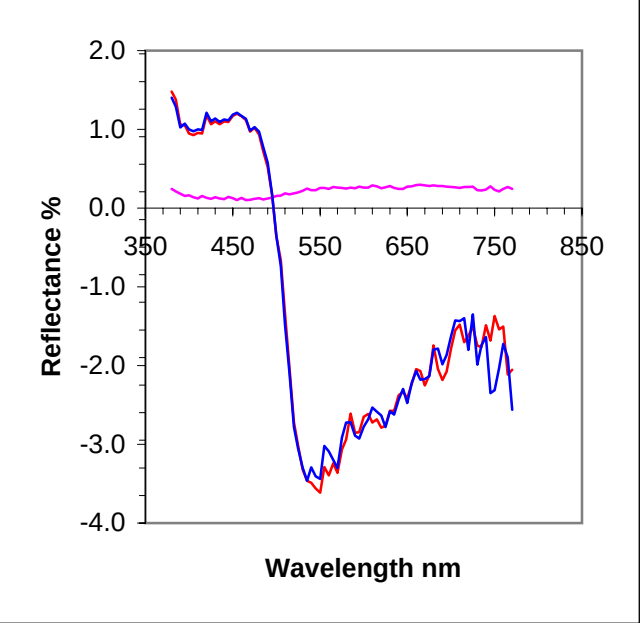
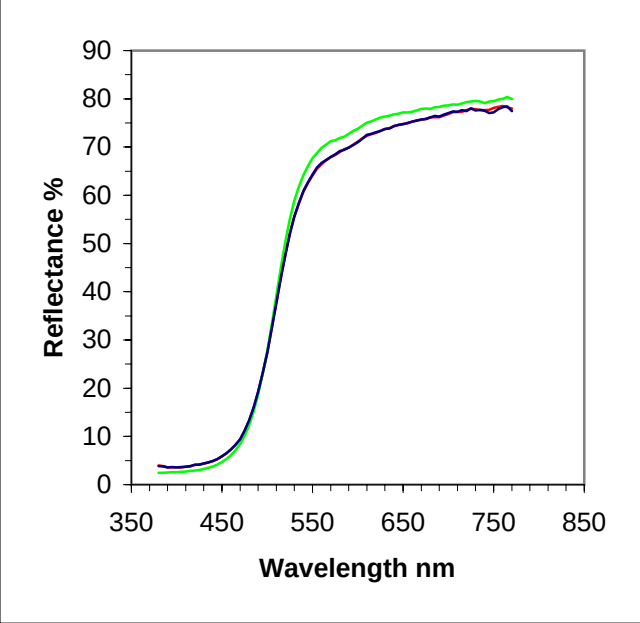
**Red
Gloss**



**Cyan
Gloss**



**Blue
Gloss**



**Yellow
Gloss**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 4

Aperture: Normal

Geometry: 45°/0°

Tiles: Matt

NPL Master Tiles: Colours CCM6

White WT45

Black BT10

Grey GT41

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0236	R%	+	0.9390	
450 nm	Uncert =	0.0216	R%	+	1.0828	
500 nm	Uncert =	0.0187	R%	+	1.1811	
550 nm	Uncert =	0.0258	R%	+	0.9113	
600 nm	Uncert =	0.0214	R%	+	0.8578	
650 nm	Uncert =	0.0214	R%	+	0.5940	
700 nm	Uncert =	0.0164	R%	+	0.7623	
<= 460 nm	Uncert =	0.024	R%	+	1.100	(k = 2)
>= 465 nm	Uncert =	0.026	R%	+	1.200	(k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	1.84	3.77
a*	0.15	1.40
b*	0.21	2.00

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0152	R%	+	1.0241	
450 nm	Uncert =	0.0186	R%	+	1.1111	
500 nm	Uncert =	0.0196	R%	+	1.1743	
550 nm	Uncert =	0.0243	R%	+	0.9206	
600 nm	Uncert =	0.0181	R%	+	0.8834	
650 nm	Uncert =	0.0200	R%	+	0.6068	
700 nm	Uncert =	0.0173	R%	+	0.7509	
<= 460 nm	Uncert =	0.019	R%	+	1.200	(k = 2)
>= 460 nm	Uncert =	0.025	R%	+	1.200	(k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	1.81	3.75
a*	0.14	1.37
b*	0.30	1.86

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	3.49	2.85	1.95	1.96	1.45	1.61	1.60	2.14	2.86	1.83	1.85	1.79	1.36	1.35	2.47
x	0.0002	0.0002	0.0003	0.0003	0.0014	0.0044	0.0108	0.0064	0.0029	0.0021	0.0018	0.0042	0.0088	0.0045	0.0003
y	0.0003	0.0004	0.0006	0.0004	0.0018	0.0021	0.0011	0.0017	0.0032	0.0026	0.0031	0.0036	0.0149	0.0049	0.0005
L*	1.48	1.51	1.76	1.75	2.78	2.18	2.22	1.66	1.51	1.85	1.84	1.89	3.61	3.77	1.56
a*	0.07	0.08	0.09	0.06	0.10	0.96	1.40	0.45	0.15	0.67	0.68	0.19	1.16	0.08	0.08
b*	0.17	0.18	0.21	0.17	0.39	0.12	0.67	1.20	1.15	0.06	0.13	0.69	2.00	0.80	0.19

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

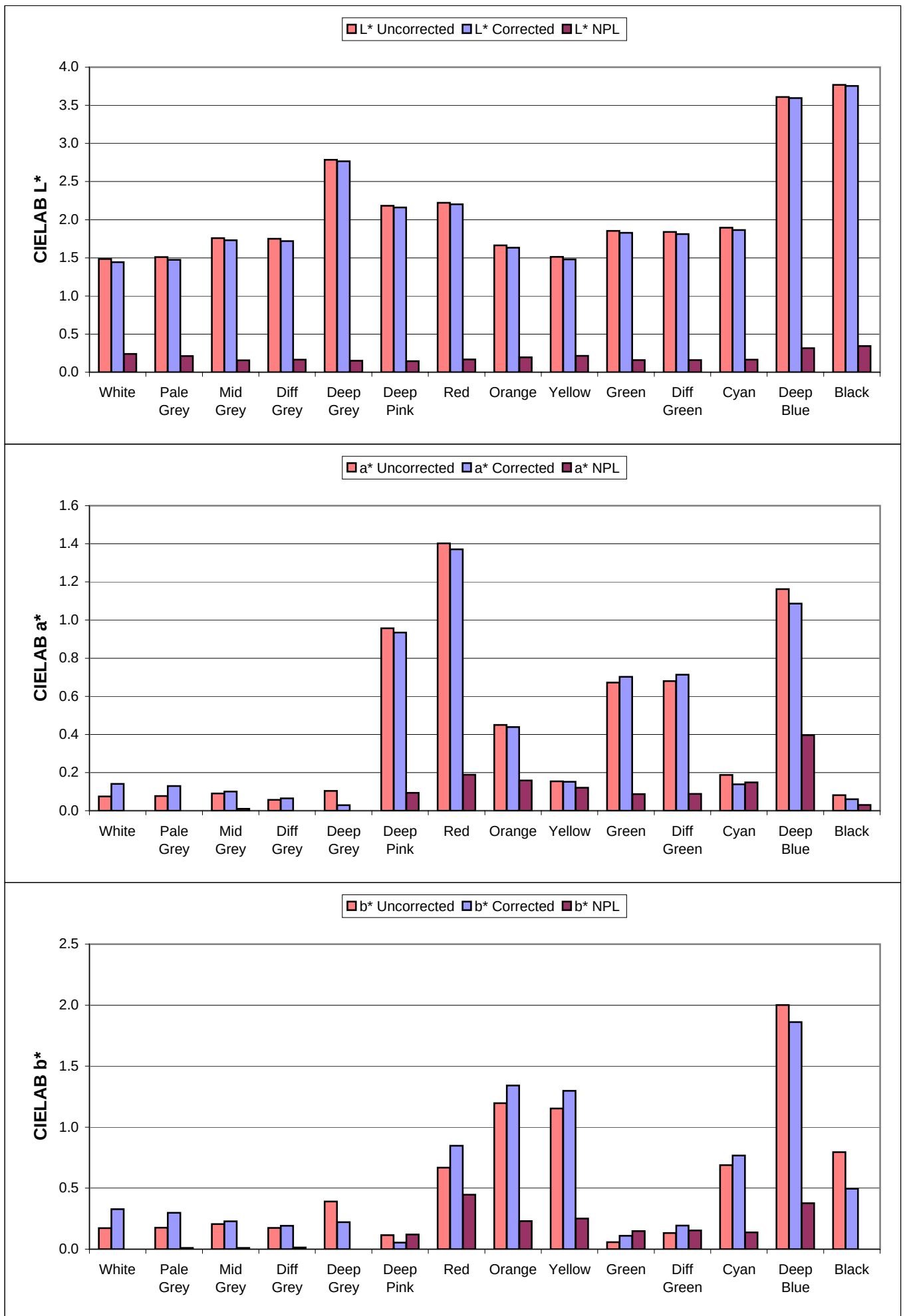
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	3.40	2.78	1.92	1.94	1.44	1.60	1.59	2.11	2.80	1.81	1.83	1.77	1.35	1.35	2.42
x	0.0004	0.0004	0.0004	0.0003	0.0010	0.0046	0.0113	0.0066	0.0031	0.0020	0.0017	0.0042	0.0084	0.0036	0.0004
y	0.0007	0.0007	0.0007	0.0004	0.0010	0.0018	0.0006	0.0019	0.0034	0.0028	0.0033	0.0038	0.0142	0.0032	0.0007
L*	1.44	1.47	1.73	1.72	2.77	2.16	2.20	1.63	1.48	1.83	1.81	1.87	3.59	3.75	1.53
a*	0.14	0.13	0.10	0.06	0.03	0.94	1.37	0.44	0.15	0.70	0.71	0.14	1.09	0.06	0.12
b*	0.33	0.30	0.23	0.19	0.22	0.05	0.85	1.34	1.30	0.11	0.19	0.77	1.86	0.50	0.28

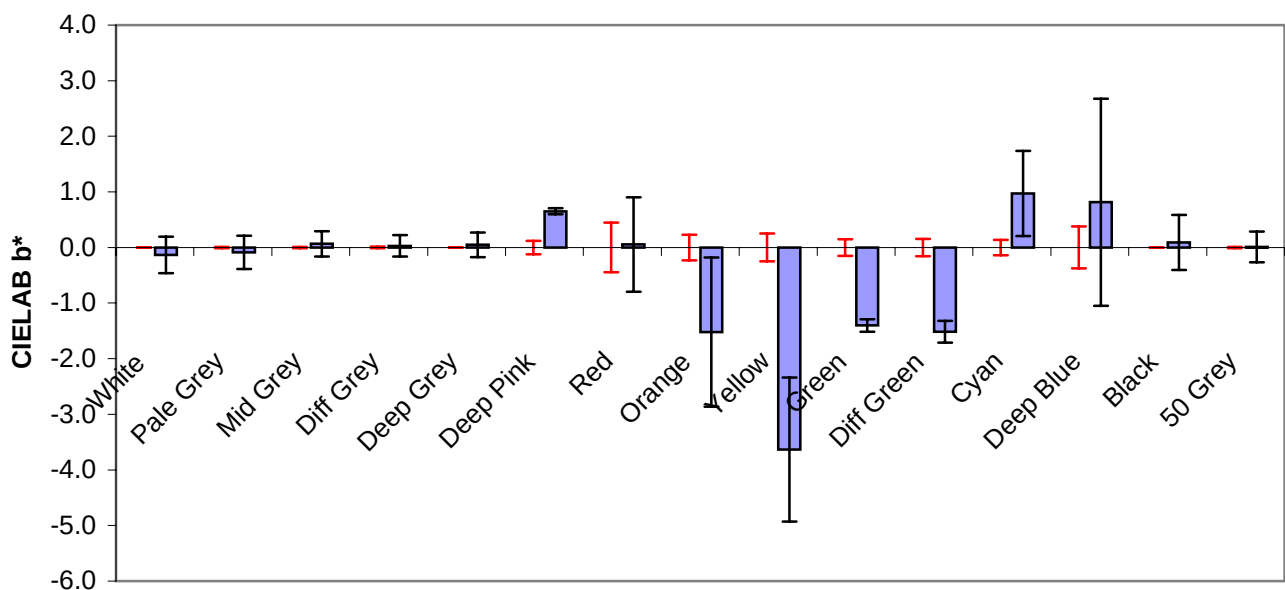
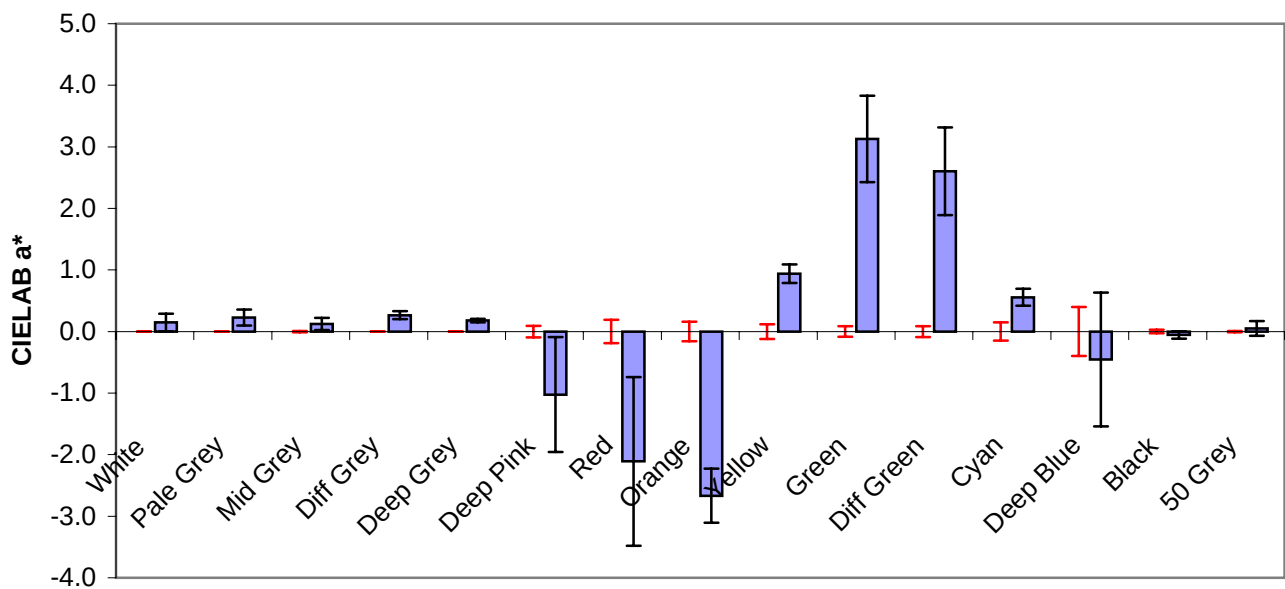
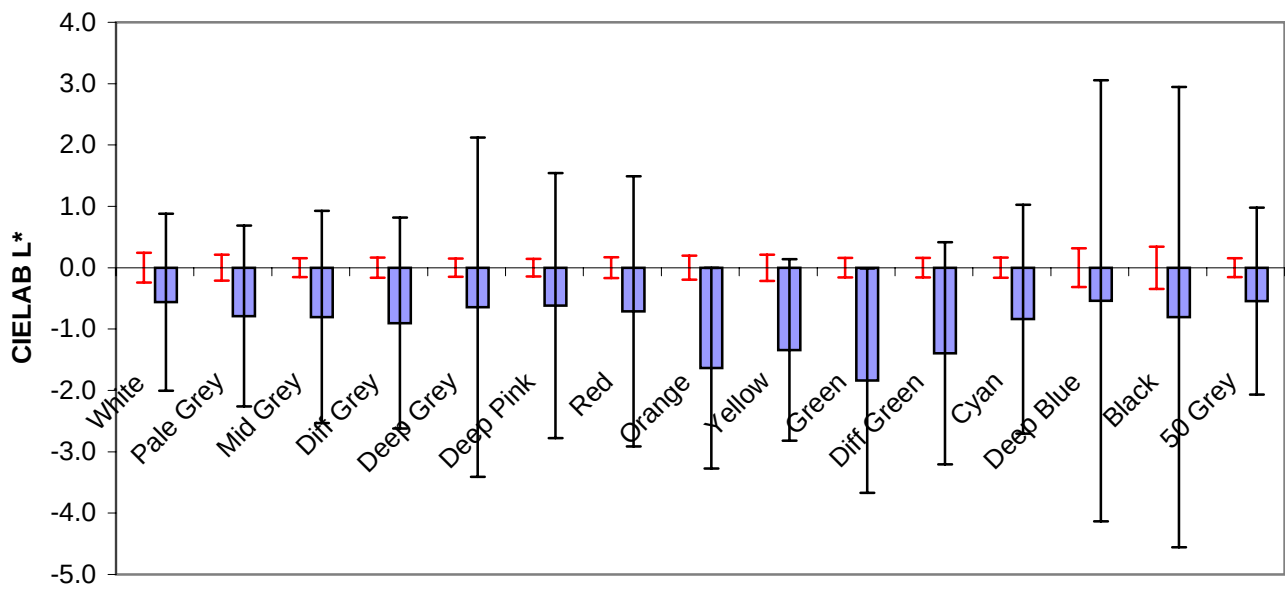
NPL Lambda Uncertainty

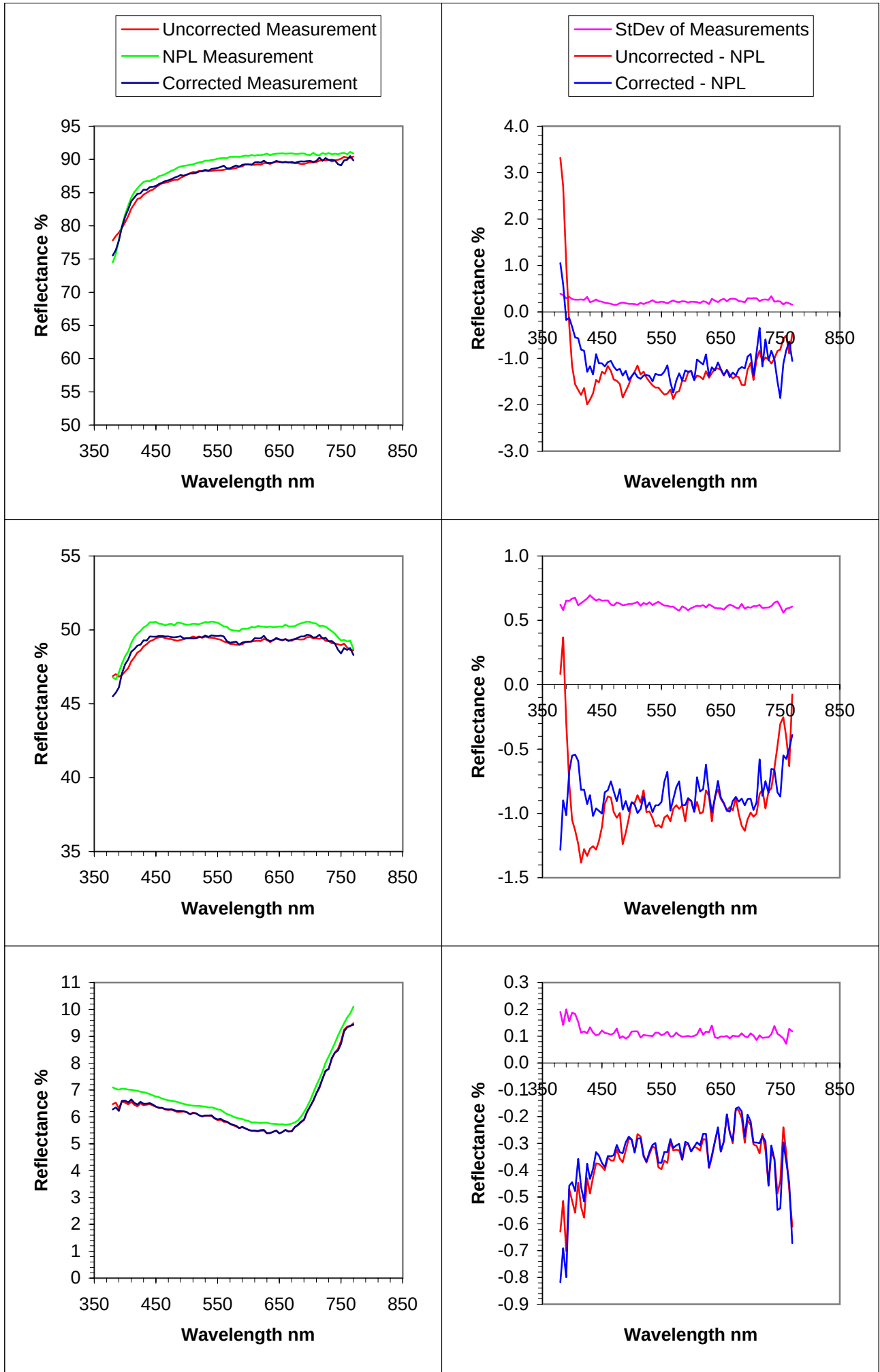
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.57	0.39	0.16	0.16	0.05	0.08	0.08	0.24	0.40	0.14	0.14	0.14	0.04	0.04	0.16
x	0.0002	0.0000	0.0000	0.0000	0.0000	0.0006	0.0016	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	0.0000
y	0.0001	0.0000	0.0000	0.0000	0.0000	0.0003	0.0001	0.0004	0.0001	0.0006	0.0005	0.0005	0.0026	0.0001	0.0000
L*	0.24	0.21	0.16	0.16	0.15	0.14	0.17	0.19	0.21	0.16	0.16	0.17	0.32	0.34	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.09	0.19	0.16	0.12	0.09	0.09	0.15	0.40	0.03	0.01
b*	< 0.01	0.01	0.01	0.01	< 0.01	0.12	0.45	0.23	0.25	0.15	0.15	0.14	0.38	< 0.01	0.01

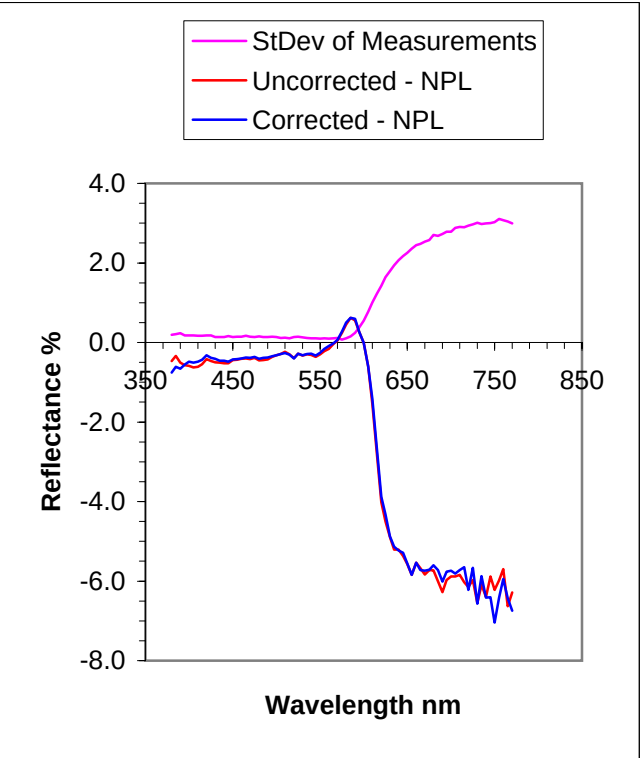
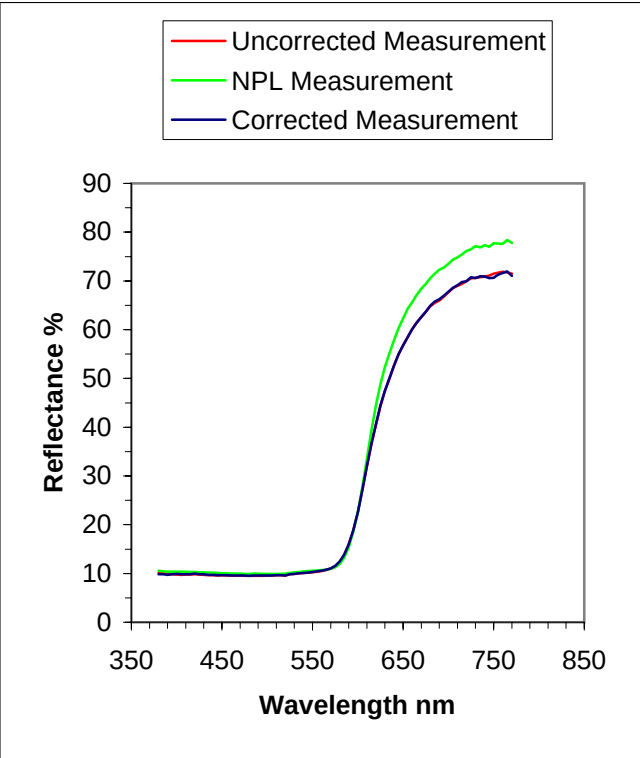
Colorimetry

			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	95.40	84.15	61.11	61.32	37.33	47.38	46.52	66.70	83.99	56.13	57.57	55.14	29.98	28.89	75.93
		a*	-0.26	-0.28	-0.12	-1.77	-0.55	22.48	36.36	34.37	-3.30	-24.41	-26.26	-10.44	6.90	-0.93	-0.26
		b*	1.91	0.29	0.50	1.95	-0.46	3.78	16.77	44.10	69.08	9.70	12.21	-26.89	-15.86	-2.12	0.01
Average Measurement (Uncorrected)	B	L*	95.36	83.75	60.87	61.32	37.43	47.14	46.28	66.66	83.95	56.67	57.30	55.09	30.03	29.01	75.64
		a*	-0.23	-0.15	-0.13	-1.77	-0.62	22.06	34.77	34.57	-3.30	-25.13	-26.03	-10.55	6.92	-0.88	-0.24
		b*	1.88	0.44	0.40	2.00	-0.50	3.77	15.73	44.56	69.04	9.86	12.37	-26.94	-15.79	-2.16	0.07
Average Measurement (Corrected)	C	L*	95.44	83.82	60.92	61.38	37.47	47.19	46.32	66.72	84.03	56.72	57.35	55.14	30.07	29.04	75.70
		a*	-0.16	-0.08	-0.08	-1.72	-0.58	22.10	34.80	34.58	-3.30	-25.09	-25.99	-10.45	6.99	-0.84	-0.18
		b*	1.77	0.33	0.32	1.92	-0.56	3.69	15.68	44.53	69.06	9.80	12.32	-27.06	-15.89	-2.22	-0.03
NPL Values	D	L*	96.00	84.61	61.72	62.28	38.12	47.80	47.03	68.36	85.37	58.55	58.74	55.98	30.61	29.85	76.25
		a*	-0.30	-0.30	-0.20	-1.98	-0.76	23.12	36.91	37.25	-4.23	-28.22	-28.59	-11.00	7.44	-0.79	-0.23
		b*	1.90	0.41	0.25	1.89	-0.61	3.04	15.63	46.05	72.69	11.20	13.83	-28.03	-16.70	-2.31	-0.04
A to B		dE*	0.059	0.439	0.260	0.055	0.131	0.480	1.912	0.503	0.049	0.915	0.387	0.125	0.087	0.139	0.296
B to C		dE*	0.160	0.147	0.113	0.109	0.080	0.095	0.074	0.067	0.075	0.088	0.085	0.164	0.119	0.072	0.135
B to D		dE*	0.645	0.873	0.874	0.986	0.704	1.448	2.274	3.506	4.021	3.855	3.279	1.473	1.190	0.855	0.619
C to D		dE*	0.596	0.825	0.815	0.940	0.670	1.362	2.227	3.479	3.984	3.890	3.318	1.399	1.075	0.813	0.546
Corrected + Uncertainty	E	L*	96.88	85.30	62.65	63.10	40.24	49.35	48.52	68.36	85.50	58.54	59.16	57.01	33.66	32.80	77.23
		a*	-0.02	0.05	0.02	-1.65	-0.55	23.03	36.18	35.02	-3.15	-24.38	-25.27	-10.31	8.07	-0.78	-0.06
		b*	2.10	0.62	0.54	2.11	-0.34	3.75	16.53	45.88	70.35	9.91	12.51	-26.29	-14.02	-1.72	0.25
Corrected - Uncertainty	F	L*	93.99	82.35	59.19	59.66	34.71	45.03	44.12	65.09	82.55	54.89	55.54	53.27	26.47	25.29	74.18
		a*	-0.30	-0.21	-0.18	-1.78	-0.61	21.16	33.43	34.14	-3.45	-25.79	-26.70	-10.58	5.90	-0.90	-0.30
		b*	1.44	0.03	0.09	1.73	-0.78	3.64	14.83	43.19	67.76	9.69	12.12	-27.83	-17.75	-2.71	-0.31

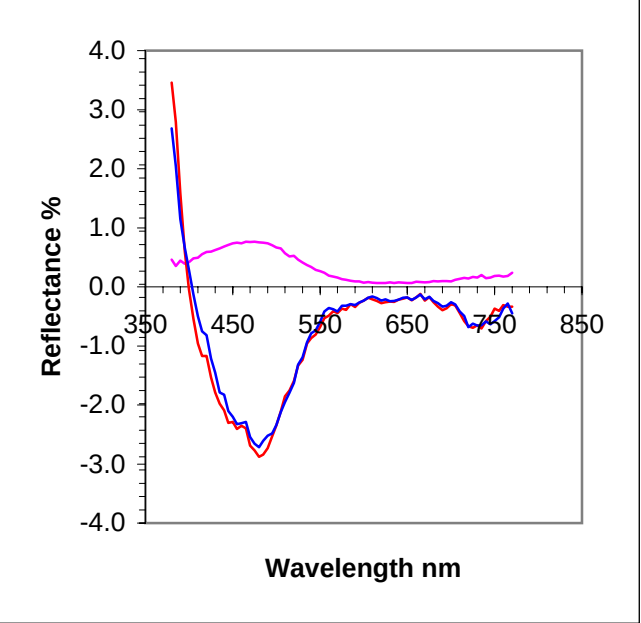
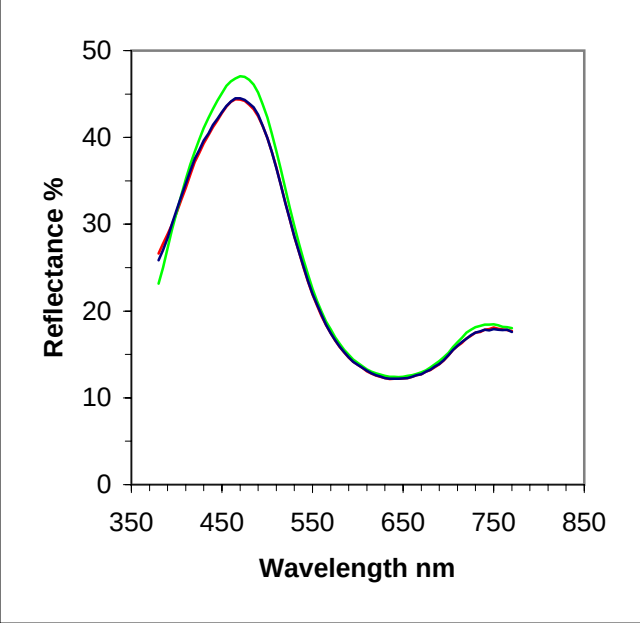




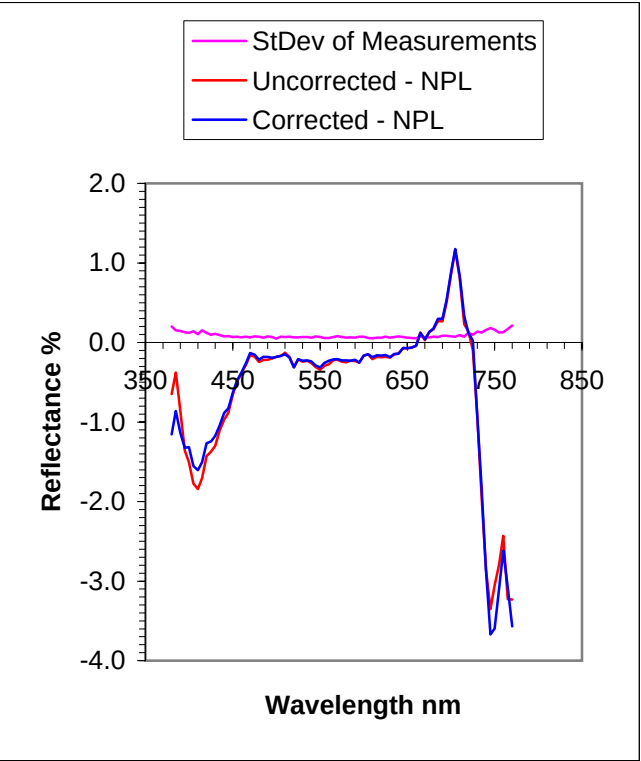
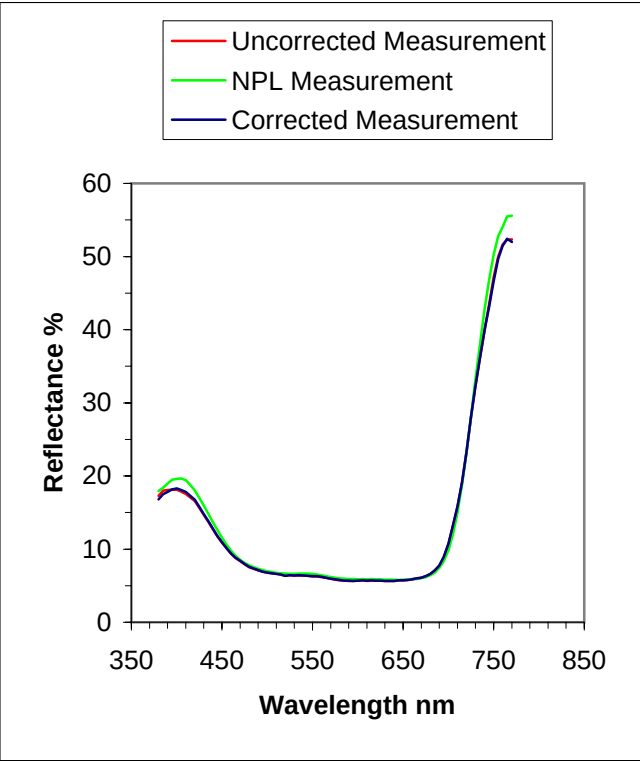




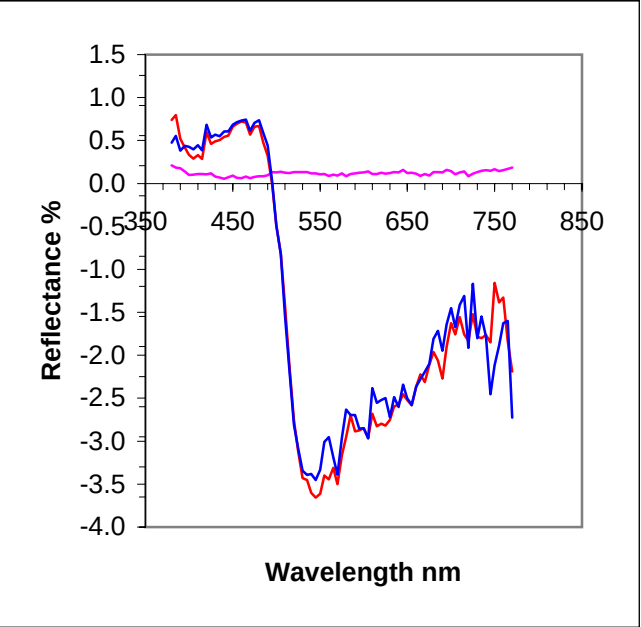
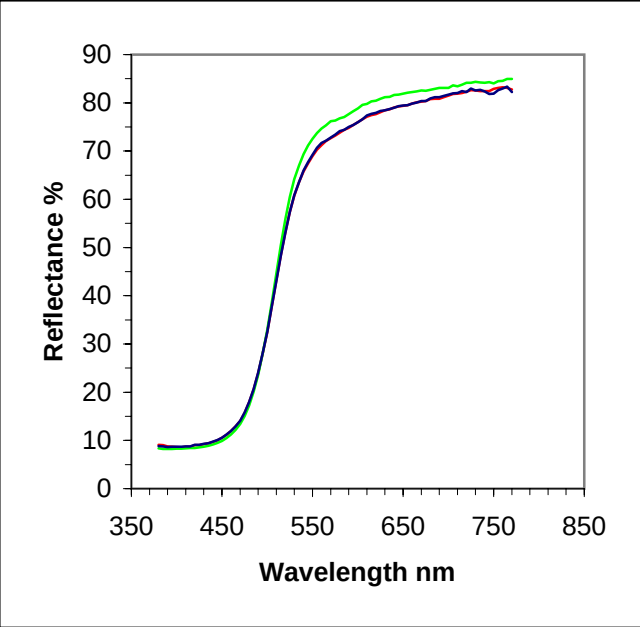
**Red
Matt**



**Cyan
Matt**



**Blue
Matt**



**Yellow
Matt**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 5

Aperture: Normal

Geometry: 45°/0°

Tiles: Gloss

NPL Master Tiles: Colours CCS3

White WT56

Black BT03

Grey GT51

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0118	R%	+	1.1915	
450 nm	Uncert =	0.0302	R%	+	0.2138	
500 nm	Uncert =	0.0356	R%	+	0.2868	
550 nm	Uncert =	0.0213	R%	+	0.5584	
600 nm	Uncert =	0.0248	R%	+	0.6371	
650 nm	Uncert =	0.0301	R%	+	0.7612	
700 nm	Uncert =	0.0507	R%	+	0.6578	
<= 460 nm	Uncert =	0.030	R%	+	1.200	(k = 2)
>= 465 nm	Uncert =	0.050	R%	+	0.800	(k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	2.12	7.55
a*	0.33	6.58
b*	0.66	7.75

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0088	R%	+	1.1476	
450 nm	Uncert =	0.0108	R%	+	0.2601	
500 nm	Uncert =	0.0077	R%	+	0.6957	
550 nm	Uncert =	0.0088	R%	+	1.0343	
600 nm	Uncert =	0.0106	R%	+	1.1590	
650 nm	Uncert =	0.0114	R%	+	1.2592	
700 nm	Uncert =	0.0112	R%	+	1.3118	
<= 460 nm	Uncert =	0.011	R%	+	1.200	(k = 2)
>= 460 nm	Uncert =	0.011	R%	+	1.300	(k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	1.76	11.79
a*	0.53	10.24
b*	0.67	13.12

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	5.33	3.81	2.03	2.05	1.05	1.37	1.31	2.48	3.89	1.80	1.83	1.72	0.87	0.84	3.18
x	0.0007	0.0006	0.0002	0.0002	0.0046	0.0082	0.0304	0.0081	0.0034	0.0018	0.0012	0.0041	0.0373	0.0236	0.0006
y	0.0014	0.0012	0.0004	< 0.0001	0.0088	0.0003	0.0042	0.0034	0.0042	0.0072	0.0080	0.0041	0.0649	0.1373	0.0011
L*	2.24	2.11	2.06	2.05	3.29	2.35	2.44	2.04	2.12	2.10	2.10	2.12	7.23	7.55	2.06
a*	0.33	0.26	0.05	0.02	0.62	0.62	1.12	0.27	0.17	0.84	0.81	0.09	6.58	1.90	0.21
b*	0.66	0.50	0.11	0.07	1.34	0.59	7.75	2.80	1.69	0.66	0.79	0.45	6.45	3.81	0.40

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

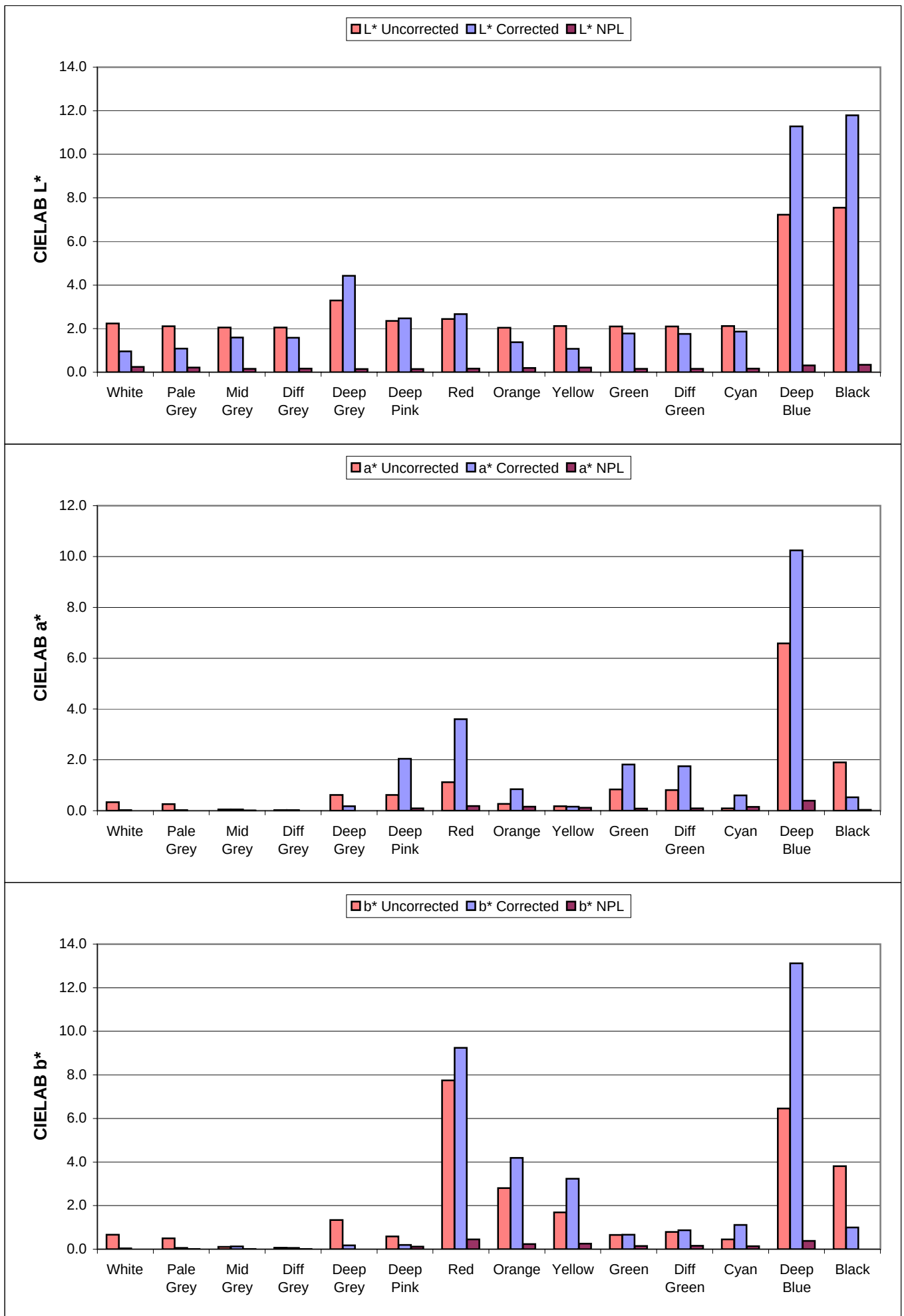
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	2.28	1.95	1.56	1.57	1.35	1.42	1.41	1.66	1.97	1.51	1.52	1.50	1.31	1.31	1.81
x	< 0.0001	< 0.0001	0.0003	0.0002	0.0003	0.0108	0.0407	0.0106	0.0043	0.0039	0.0031	0.0065	0.0751	0.0234	0.0002
y	< 0.0001	0.0001	0.0004	< 0.0001	0.0007	0.0037	0.0003	0.0031	0.0047	0.0081	0.0091	0.0053	0.1342	0.0118	0.0003
L*	0.96	1.08	1.59	1.58	4.43	2.47	2.67	1.37	1.08	1.78	1.76	1.86	11.28	11.79	1.18
a*	0.02	0.03	0.05	0.03	0.18	2.04	3.60	0.85	0.16	1.82	1.75	0.60	10.24	0.53	0.03
b*	0.04	0.06	0.12	0.06	0.17	0.19	9.24	4.19	3.23	0.67	0.87	1.11	13.12	0.99	0.09

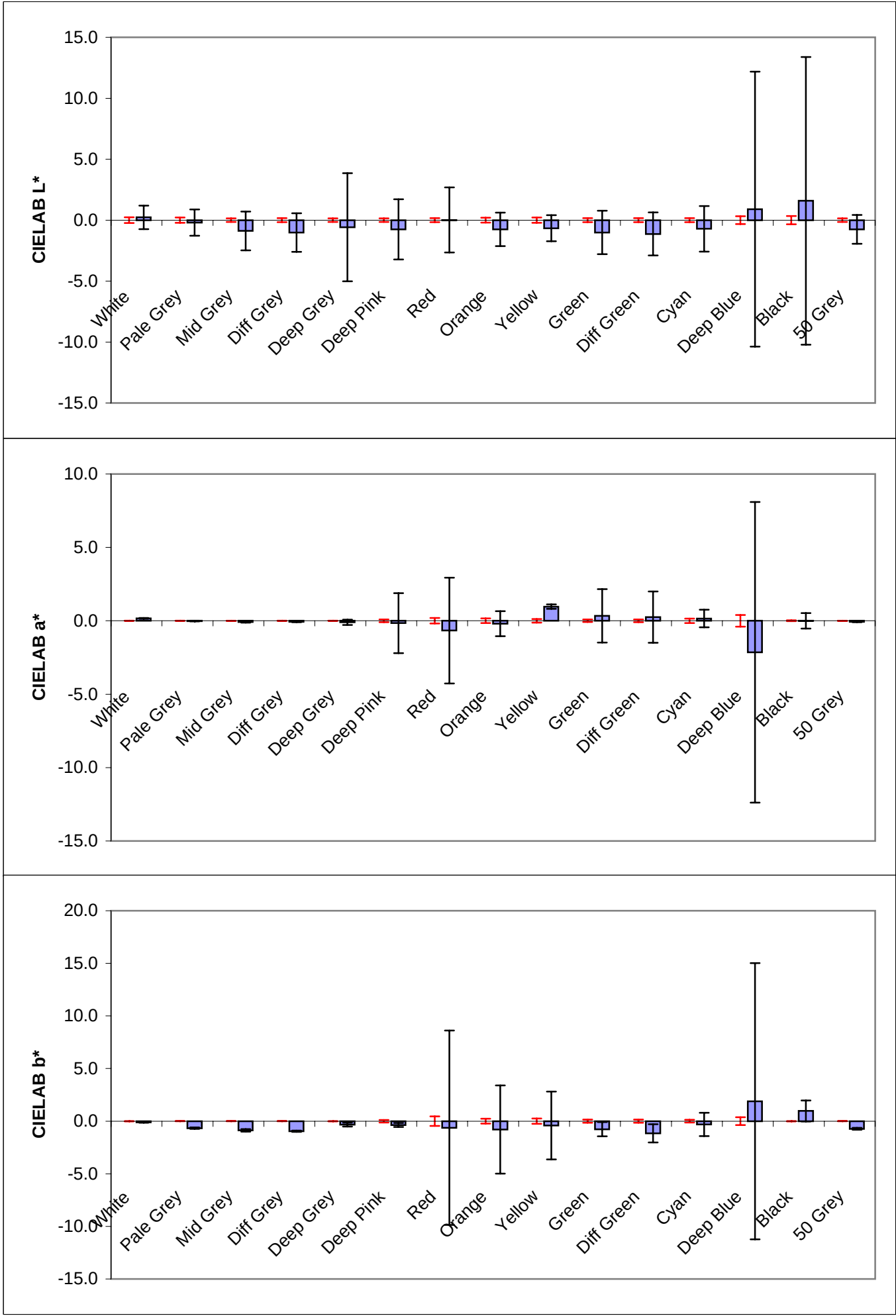
NPL Lambda Uncertainty

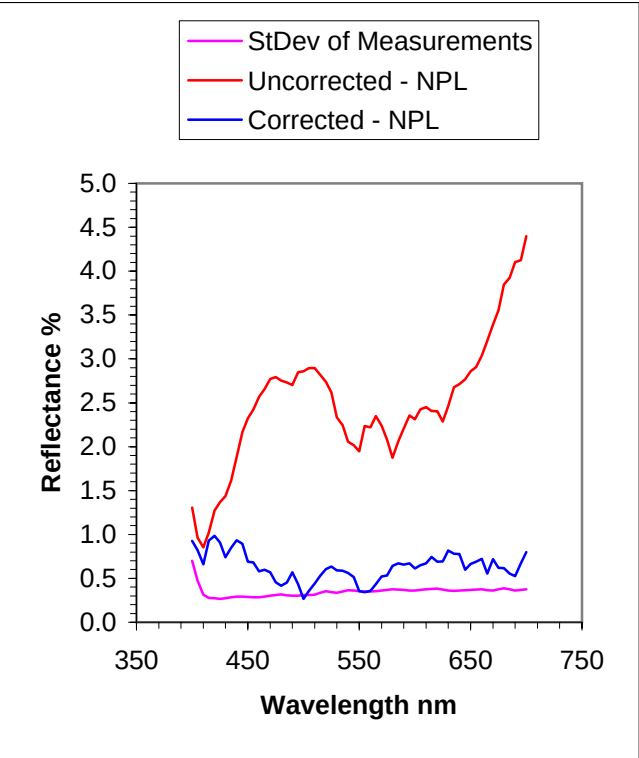
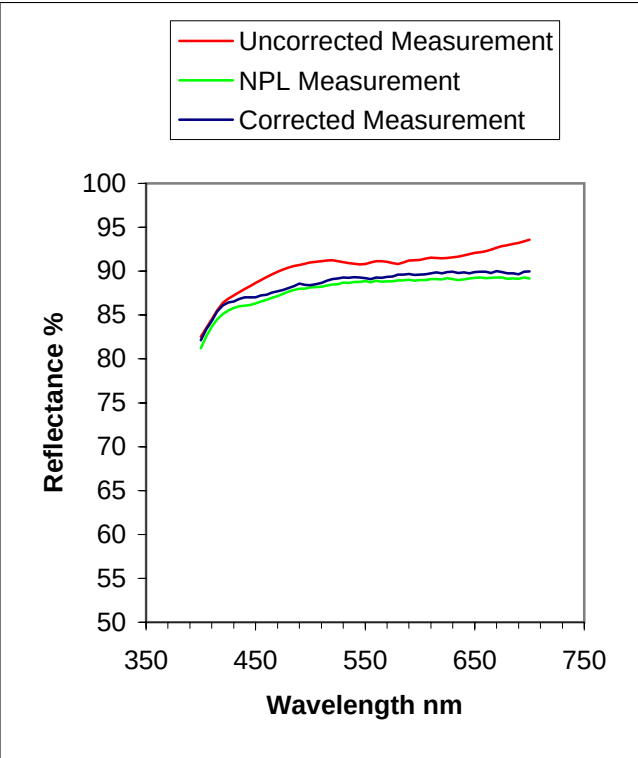
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.57	0.39	0.16	0.16	0.05	0.08	0.08	0.24	0.40	0.14	0.14	0.14	0.04	0.04	0.16
x	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0006	0.0016	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	< 0.0001
y	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0001	0.0004	0.0001	0.0006	0.0005	0.0005	0.0026	0.0001	< 0.0001
L*	0.24	0.21	0.16	0.16	0.15	0.14	0.17	0.19	0.21	0.16	0.16	0.17	0.32	0.34	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.09	0.19	0.16	0.12	0.09	0.09	0.15	0.40	0.03	0.01
b*	< 0.01	0.01	0.01	0.01	< 0.01	0.12	0.45	0.23	0.25	0.15	0.15	0.14	0.38	< 0.01	0.01

Colorimetry

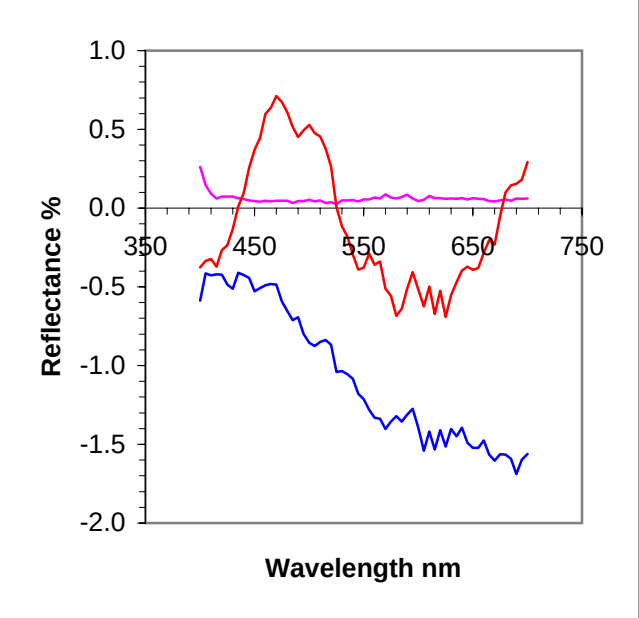
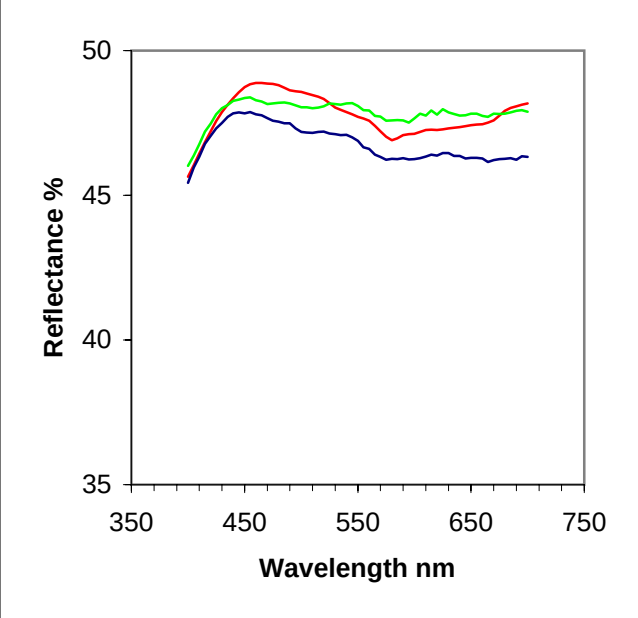
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	96.46	82.13	56.77	57.03	26.33	40.31	38.17	64.68	82.73	51.87	52.36	50.02	11.84	5.47	74.63
		a*	-0.46	-0.53	-0.35	-2.78	-0.12	29.10	52.73	41.89	-3.43	-35.41	-35.10	-13.35	18.64	-1.94	-0.39
		b*	1.56	-0.01	-0.20	1.73	0.98	4.71	37.05	62.91	83.62	15.26	18.62	-33.51	-29.54	0.64	-0.89
Average Measurement (Uncorrected)	B	L*	96.43	82.09	56.73	57.06	26.32	40.29	38.08	64.54	82.72	51.87	52.39	50.04	11.84	5.62	74.63
		a*	-0.50	-0.63	-0.38	-2.72	-0.22	28.89	52.68	41.80	-3.38	-35.43	-35.17	-13.52	18.36	-1.68	-0.46
		b*	1.59	0.10	-0.22	1.72	1.06	4.68	36.89	62.56	83.75	15.37	18.62	-33.36	-29.46	0.50	-0.86
Average Measurement (Corrected)	C	L*	95.68	81.44	56.24	56.58	26.04	39.92	37.72	64.04	82.08	51.41	51.93	49.57	11.66	5.51	74.02
		a*	-0.25	-0.40	-0.21	-2.54	-0.13	28.75	52.30	41.52	-3.31	-35.03	-34.78	-13.11	18.46	-1.61	-0.25
		b*	1.44	-0.03	-0.31	1.62	1.00	4.54	36.60	62.14	83.28	15.25	18.49	-33.28	-29.43	0.47	-0.98
NPL Values	D	L*	95.45	81.63	57.13	57.60	26.62	40.68	37.71	64.80	82.75	52.42	53.06	50.28	10.75	3.93	74.78
		a*	-0.41	-0.38	-0.14	-2.48	-0.03	28.91	52.97	41.72	-4.27	-35.36	-35.03	-13.26	20.60	-1.61	-0.19
		b*	1.54	0.63	0.56	2.58	1.33	4.90	37.23	62.93	83.69	16.02	19.65	-32.97	-31.32	-0.50	-0.25
A to B		dE*	0.066	0.149	0.054	0.067	0.122	0.216	0.190	0.385	0.145	0.115	0.080	0.229	0.292	0.329	0.082
B to C		dE*	0.805	0.704	0.521	0.529	0.303	0.419	0.595	0.716	0.799	0.627	0.626	0.628	0.215	0.135	0.651
B to D		dE*	0.982	0.743	0.905	1.044	0.444	0.449	0.581	0.454	0.893	0.848	1.229	0.527	3.113	1.969	0.685
C to D		dE*	0.302	0.694	1.242	1.404	0.676	0.857	0.914	1.111	1.240	1.311	1.639	0.792	2.995	1.856	1.047
Corrected + Uncertainty	E	L*	96.64	82.52	57.84	58.16	30.47	42.39	40.39	65.41	83.16	53.19	53.68	51.43	22.94	17.30	75.20
		a*	-0.22	-0.37	-0.16	-2.51	0.05	30.80	55.90	42.37	-3.15	-33.21	-33.03	-12.51	28.70	-1.08	-0.22
		b*	1.47	0.03	-0.19	1.68	1.17	4.73	45.84	66.33	86.51	15.92	19.36	-32.17	-16.31	1.47	-0.89
Corrected - Uncertainty	F	L*	94.72	80.35	54.65	54.99	21.61	37.45	35.05	62.66	81.01	49.63	50.17	47.70	0.37	-6.28	72.84
		a*	-0.27	-0.43	-0.26	-2.57	-0.30	26.71	48.70	40.67	-3.46	-36.84	-36.53	-13.71	8.22	-2.14	-0.29
		b*	1.40	-0.09	-0.43	1.56	0.82	4.35	27.36	57.95	80.05	14.59	17.62	-34.39	-42.55	-0.52	-1.06



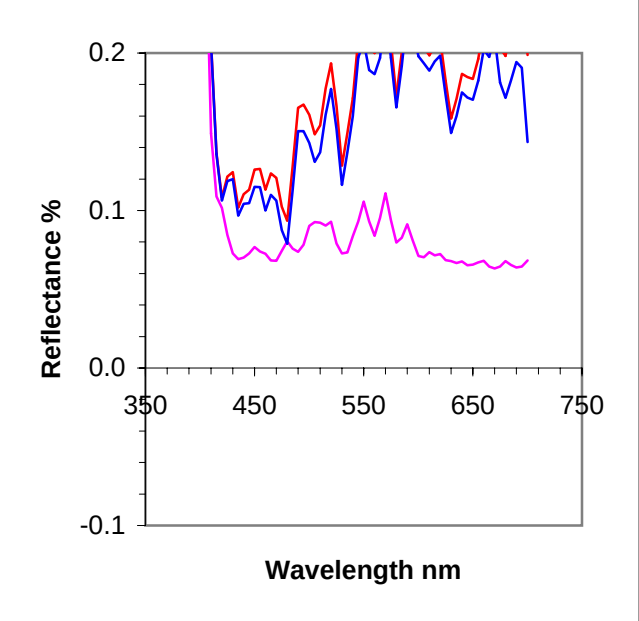
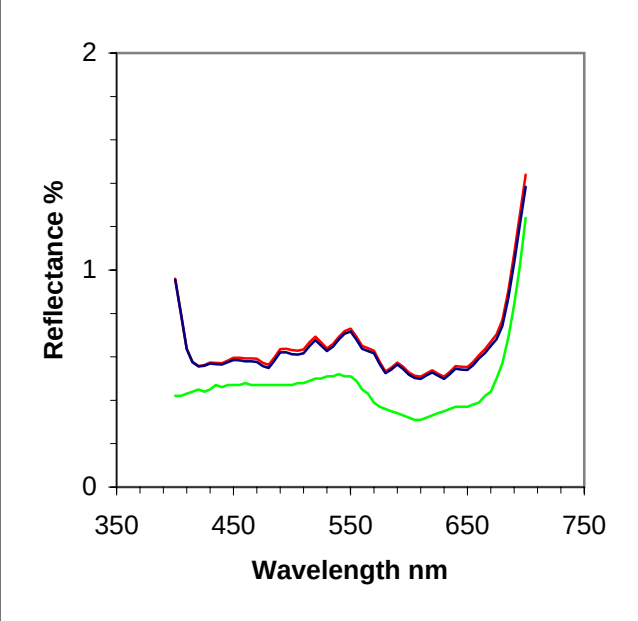




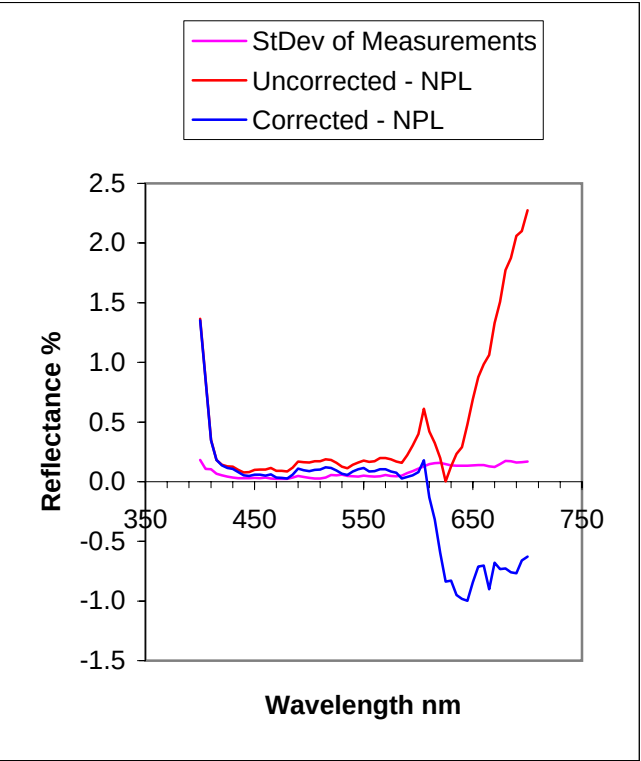
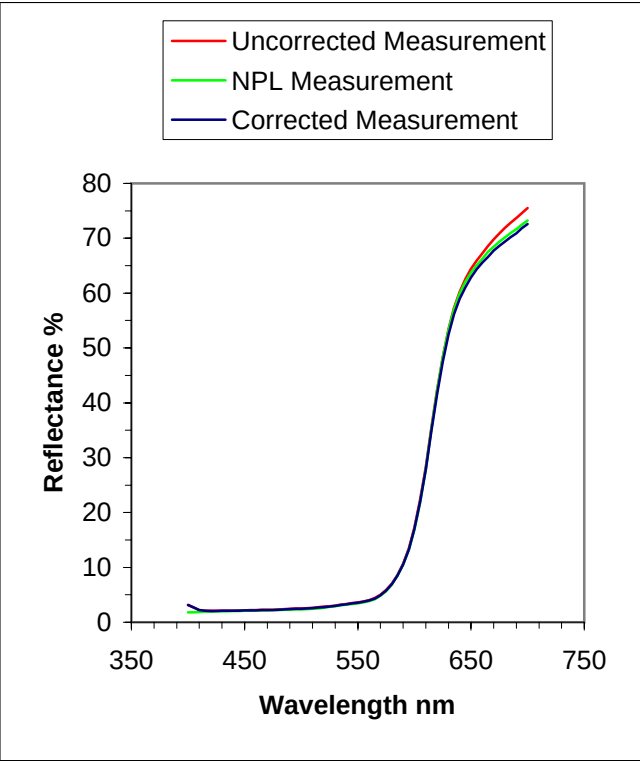
**White
Gloss**



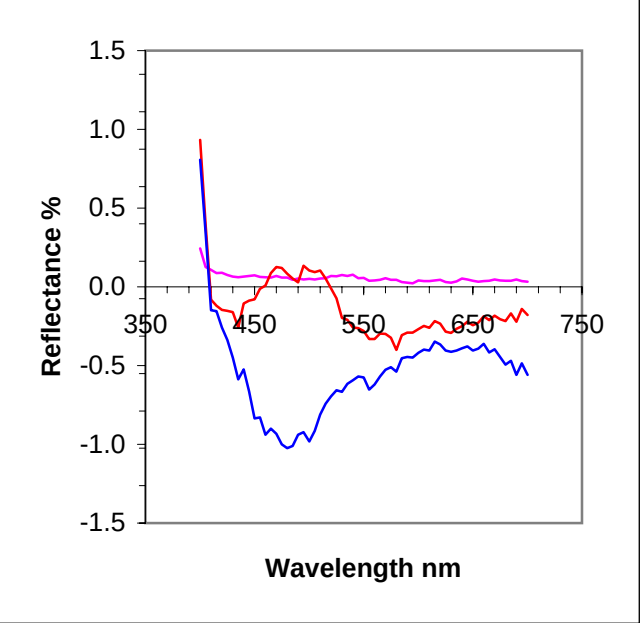
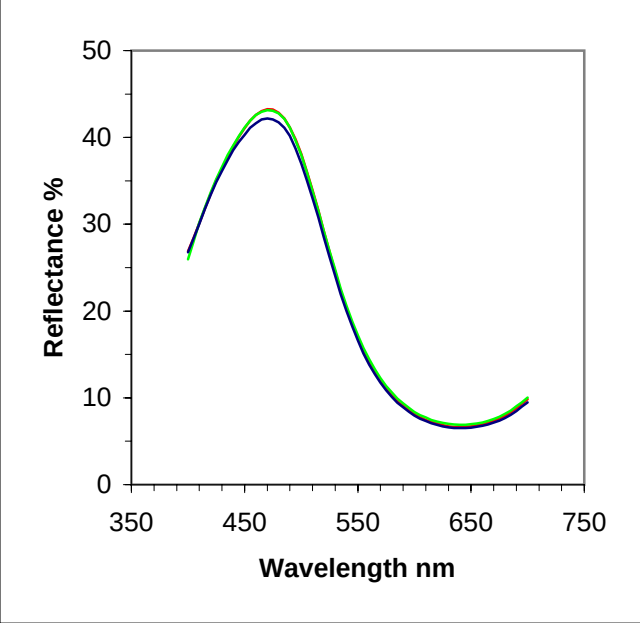
**50 Grey
Gloss**



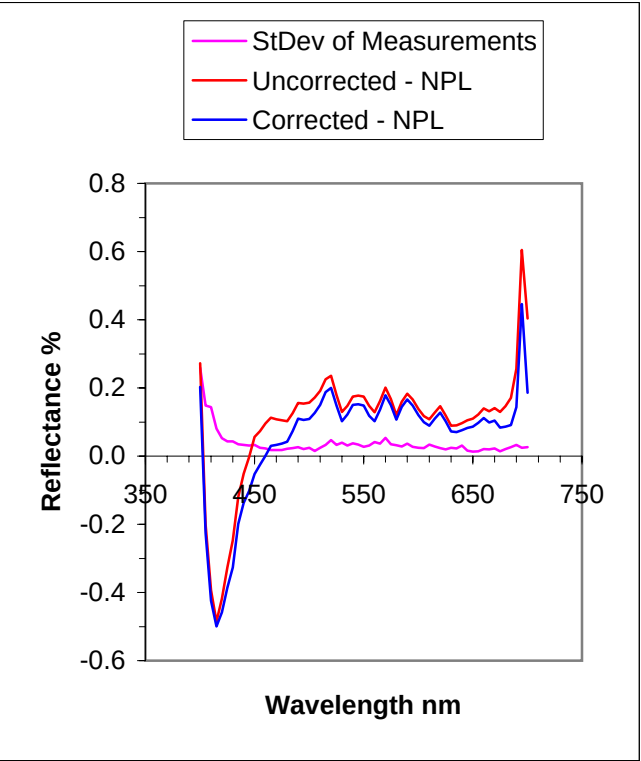
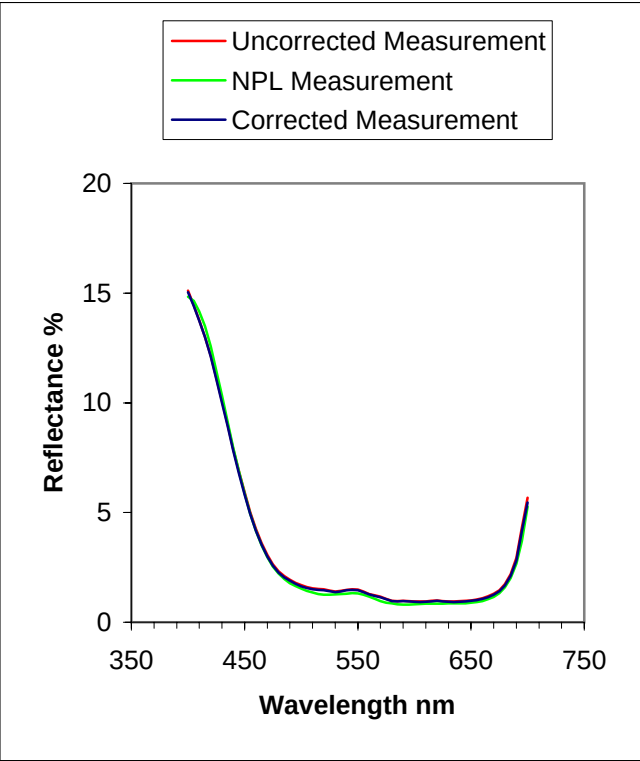
**Black
Gloss**



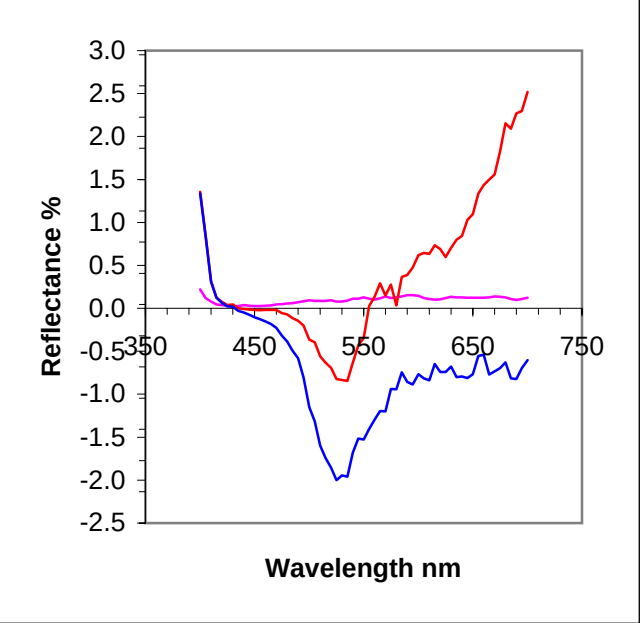
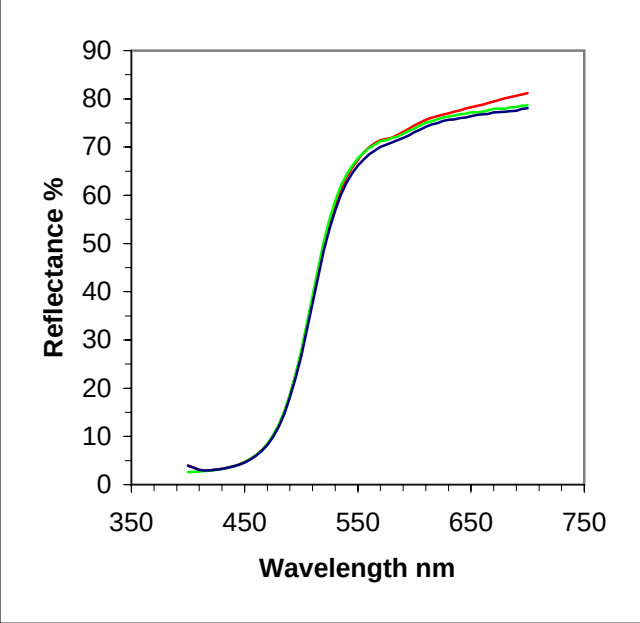
**Red
Gloss**



**Cyan
Gloss**



**Blue
Gloss**



**Yellow
Gloss**

INSTRUMENT CHARACTERISATION

Instrument: Instrument 5

Aperture: Normal

Geometry: 45°/0°

Tiles: Matt

NPL Master Tiles: Colours CCM6

White WT45

Black BT10

Grey GT41

Spectral uncertainty - Uncorrected Scale

400 nm	Uncert =	0.0049	R%	+	2.4787	
450 nm	Uncert =	0.0277	R%	+	0.8090	
500 nm	Uncert =	0.0288	R%	+	0.7524	
550 nm	Uncert =	0.0199	R%	+	0.8973	
600 nm	Uncert =	0.0223	R%	+	0.8616	
650 nm	Uncert =	0.0233	R%	+	0.5502	
700 nm	Uncert =	0.0373	R%	+	0.6806	
<= 460 nm	Uncert =	0.030	R%	+	2.500	(k = 2)
>= 465 nm	Uncert =	0.040	R%	+	1.000	(k = 2)

Colorimetric Uncertainties - Uncorrected Scale

	Median	Maximum
L*	2.01	3.24
a*	0.63	2.29
b*	1.91	3.77

Spectral uncertainty - Corrected Scale

400 nm	Uncert =	0.0037	R%	+	2.7747	
450 nm	Uncert =	0.0147	R%	+	1.5101	
500 nm	Uncert =	0.0126	R%	+	1.6778	
550 nm	Uncert =	0.0189	R%	+	2.1863	
600 nm	Uncert =	0.0196	R%	+	2.3321	
650 nm	Uncert =	0.0201	R%	+	2.3991	
700 nm	Uncert =	0.0182	R%	+	2.3183	
<= 460 nm	Uncert =	0.015	R%	+	2.500	(k = 2)
>= 460 nm	Uncert =	0.02	R%	+	2.500	(k = 2)

Colorimetric Uncertainties - Corrected Scale

	Median	Maximum
L*	3.02	7.38
a*	0.16	3.30
b*	0.61	4.24

Colorimetric Uncertainty - Uncorrected Scale - With Temperature Correction

	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	4.67	3.57	2.19	2.22	1.43	1.67	1.67	2.52	3.63	2.06	2.06	1.96	1.29	1.28	3.04
x	0.0003	0.0006	0.0017	0.0018	0.0055	0.0091	0.0166	0.0098	0.0052	0.0007	0.0011	0.0027	0.0007	0.0077	0.0008
y	0.0007	0.0012	0.0038	0.0041	0.0133	0.0060	0.0080	0.0064	0.0072	0.0099	0.0107	0.0001	0.0027	0.0206	0.0018
L*	1.95	1.89	1.97	1.96	2.64	2.24	2.25	1.92	1.90	2.01	2.01	2.04	3.21	3.24	1.89
a*	0.14	0.26	0.63	0.65	1.59	0.32	0.18	0.40	0.45	1.42	1.44	0.91	1.29	2.29	0.35
b*	0.28	0.51	1.19	1.23	2.83	2.23	3.54	3.47	3.26	1.91	2.06	0.58	1.53	3.77	0.67

Colorimetric Uncertainty - Corrected Scale - With Temperature Correction

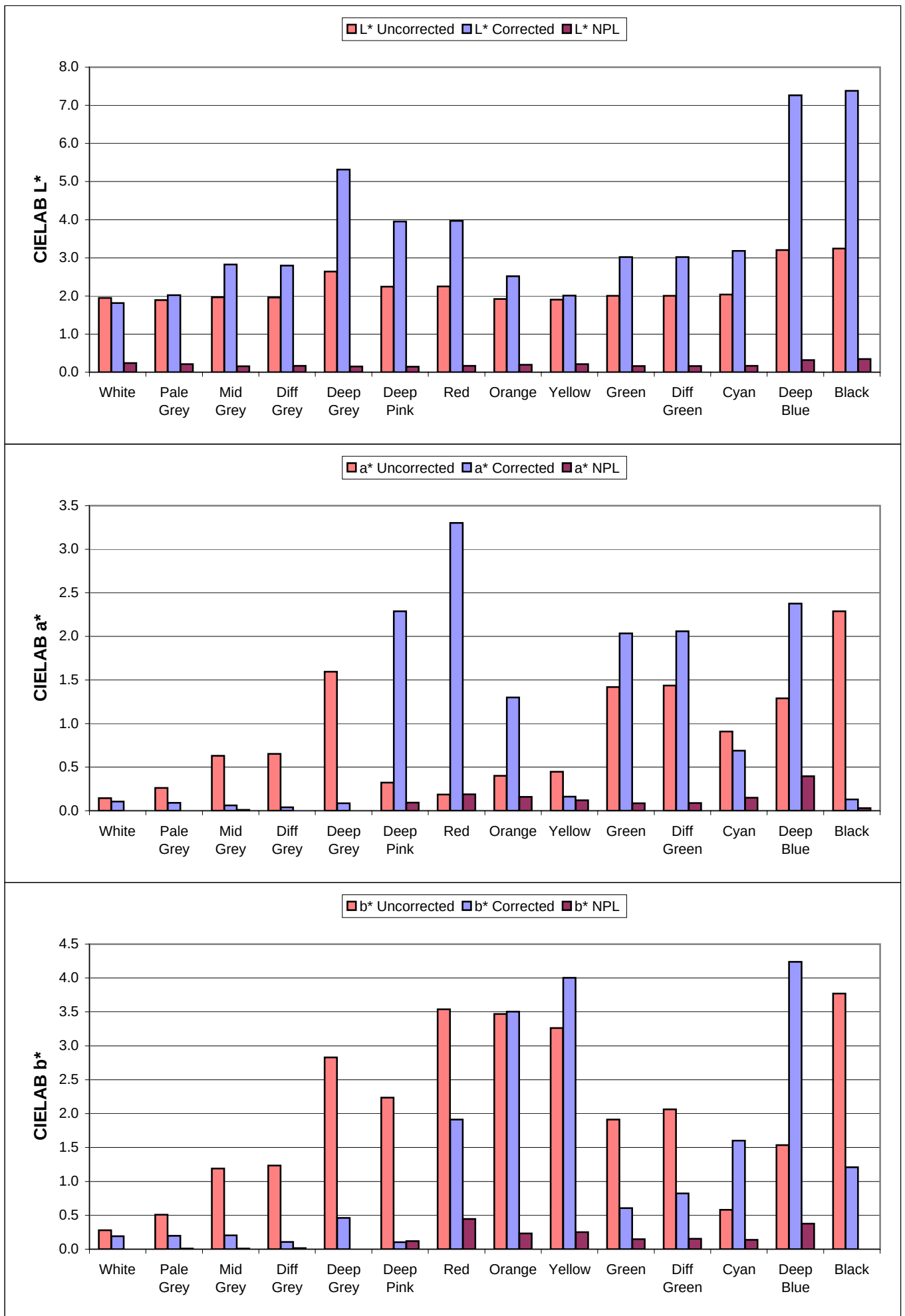
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	4.29	3.75	3.07	3.09	2.70	2.82	2.82	3.23	3.78	3.01	3.01	2.96	2.63	2.63	3.49
x	0.0002	0.0003	0.0005	0.0004	0.0030	0.0101	0.0238	0.0144	0.0069	0.0044	0.0038	0.0088	0.0197	0.0091	0.0004
y	0.0004	0.0005	0.0007	0.0001	0.0024	0.0040	0.0015	0.0042	0.0078	0.0072	0.0085	0.0072	0.0319	0.0085	0.0006
L*	1.81	2.02	2.83	2.80	5.32	3.95	3.97	2.52	2.01	3.02	3.02	3.18	7.26	7.38	2.21
a*	0.10	0.09	0.06	0.04	0.09	2.29	3.30	1.30	0.16	2.03	2.06	0.69	2.38	0.13	0.09
b*	0.19	0.20	0.20	0.11	0.46	0.10	1.91	3.51	4.00	0.61	0.82	1.60	4.24	1.21	0.21

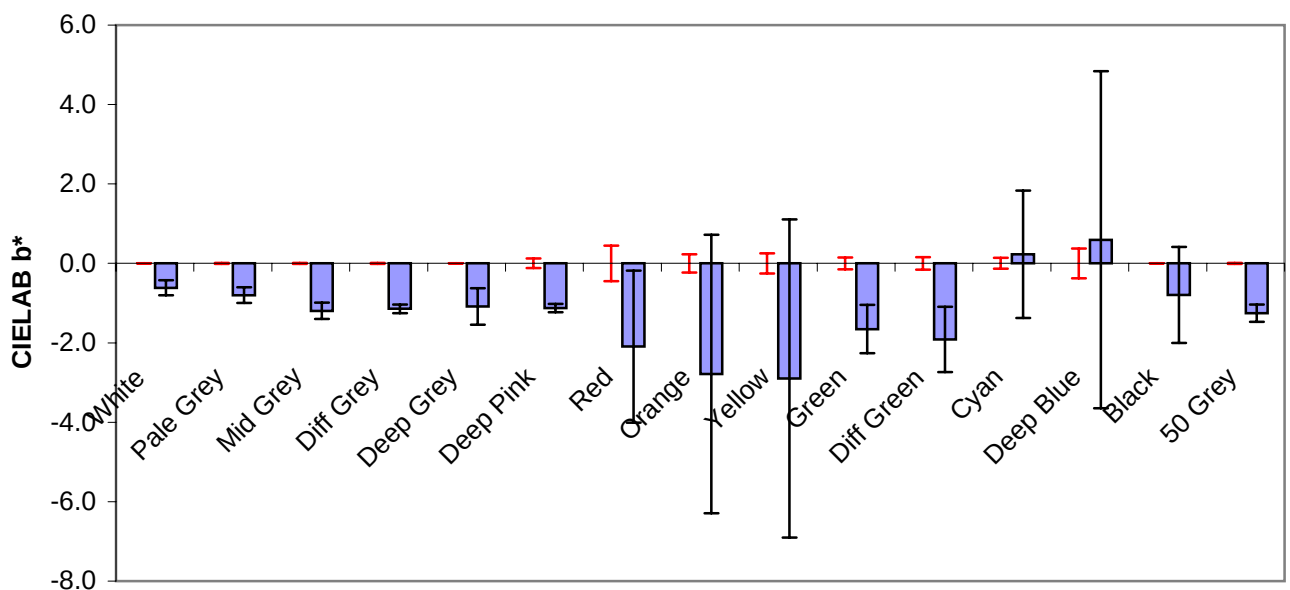
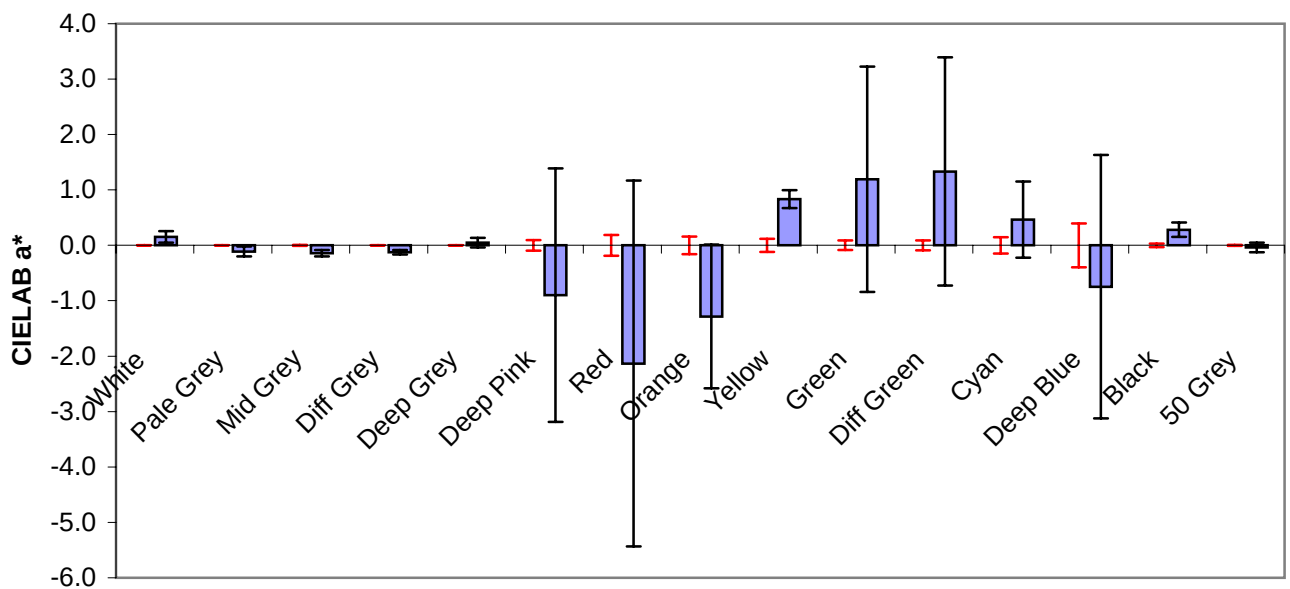
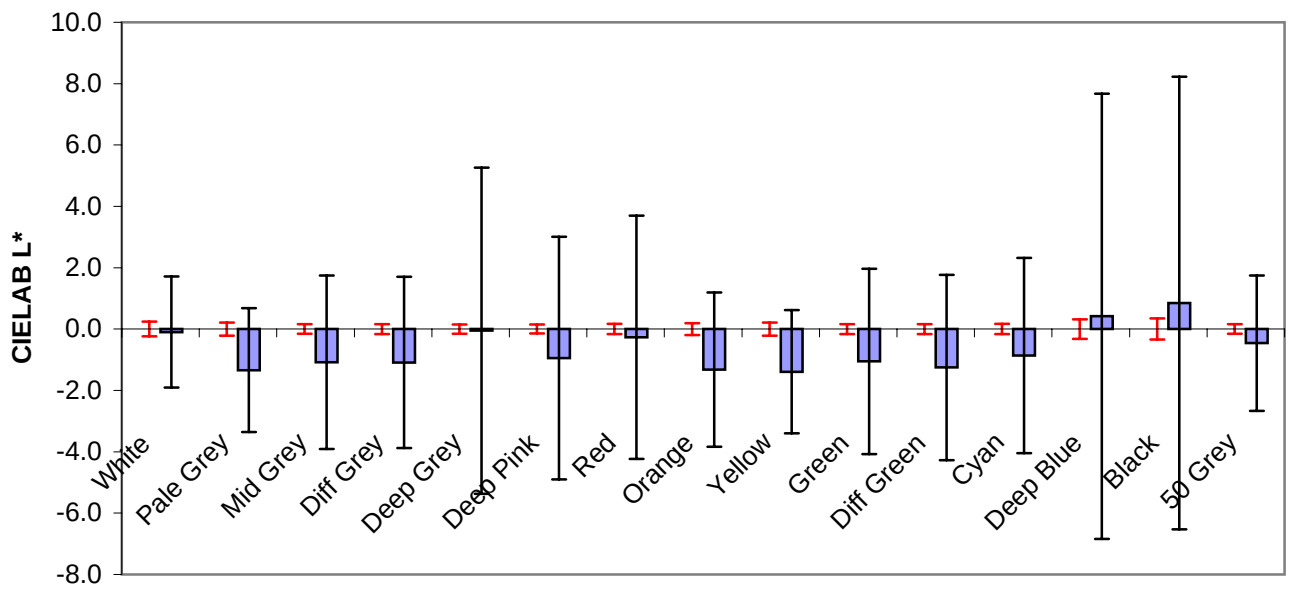
NPL Lambda Uncertainty

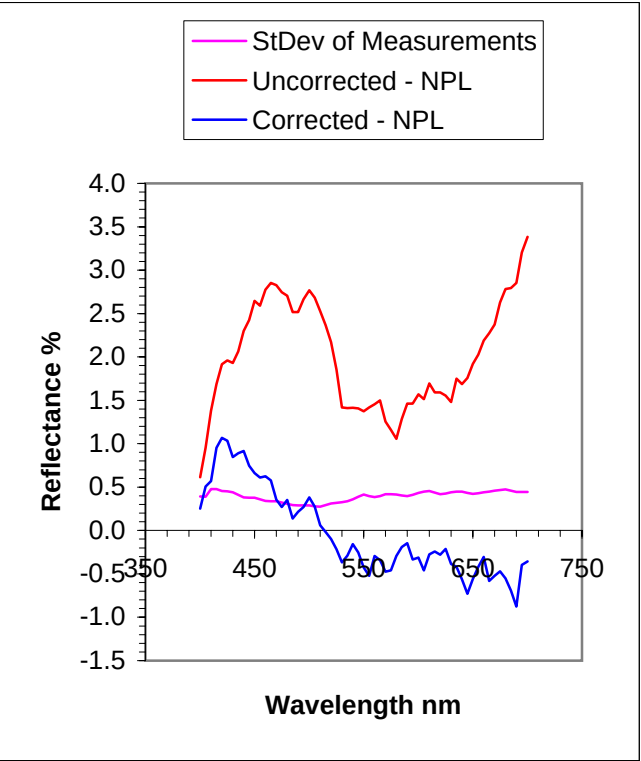
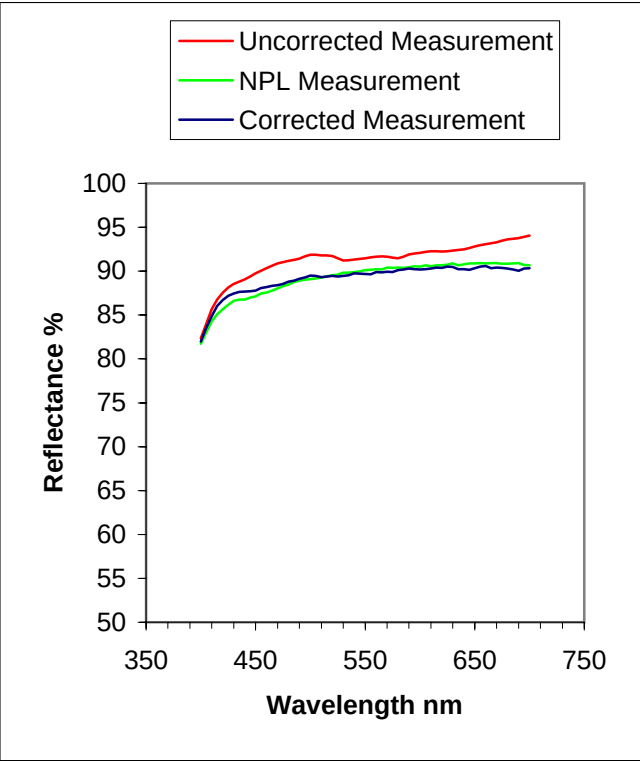
	White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
Y	0.57	0.39	0.16	0.16	0.05	0.08	0.08	0.24	0.40	0.14	0.14	0.14	0.04	0.04	0.16
x	0.0002	0.0000	0.0000	0.0000	0.0000	0.0006	0.0016	0.0004	0.0003	0.0004	0.0004	0.0002	0.0016	0.0003	0.0000
y	0.0001	0.0000	0.0000	0.0000	0.0000	0.0003	0.0001	0.0004	0.0001	0.0006	0.0005	0.0005	0.0026	0.0001	0.0000
L*	0.24	0.21	0.16	0.16	0.15	0.14	0.17	0.19	0.21	0.16	0.16	0.17	0.32	0.34	0.16
a*	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.09	0.19	0.16	0.12	0.09	0.09	0.15	0.40	0.03	0.01
b*	< 0.01	0.01	0.01	0.01	< 0.01	0.12	0.45	0.23	0.25	0.15	0.15	0.14	0.38	< 0.01	0.01

Colorimetry

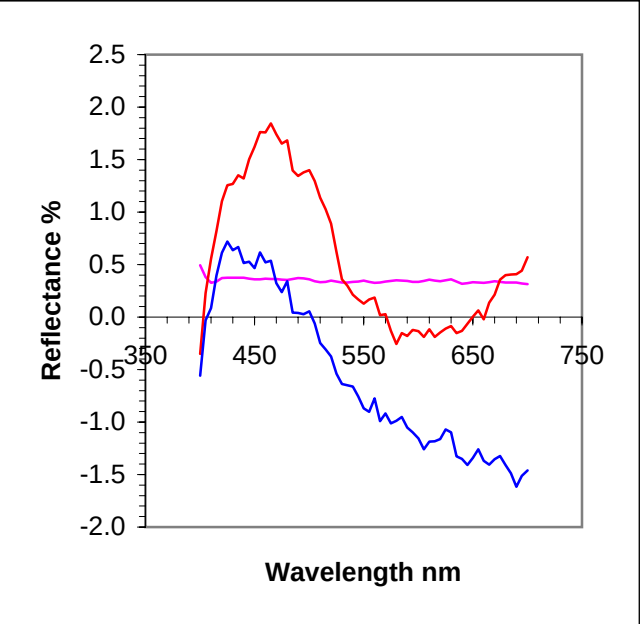
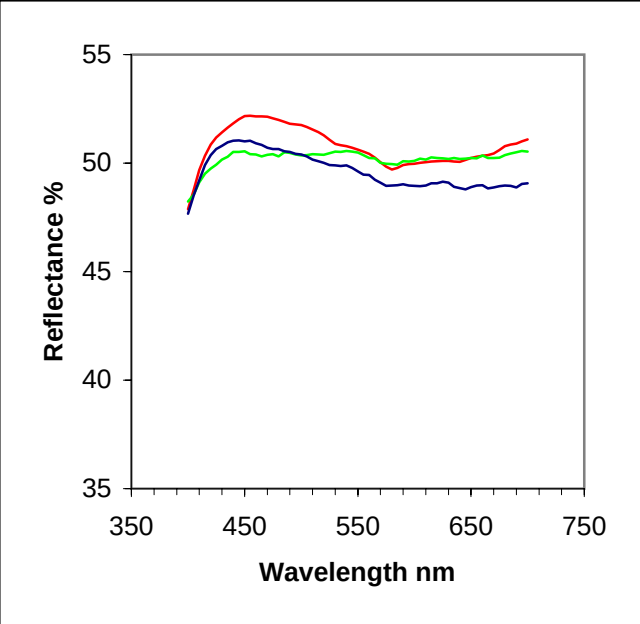
			White	Pale Grey	Mid Grey	Diff Grey	Deep Grey	Deep Pink	Red	Orange	Yellow	Green	Diff Green	Cyan	Deep Blue	Black	50 Grey
First Measurement	A	L*	96.85	84.27	61.25	61.63	38.76	47.35	47.32	67.36	84.65	58.26	57.97	55.81	31.32	31.18	76.73
		a*	-0.12	-0.42	-0.37	-2.19	-0.79	22.54	35.80	36.10	-3.30	-27.82	-27.39	-10.96	6.56	-0.49	-0.30
		b*	1.18	-0.50	-0.92	0.71	-1.73	1.97	14.07	43.10	70.23	9.73	11.93	-28.34	-16.25	-3.17	-1.33
Average Measurement (Uncorrected)	B	L*	96.68	83.96	61.18	61.73	38.44	47.29	47.19	67.59	84.65	58.02	58.01	55.63	31.34	31.02	76.43
		a*	-0.26	-0.52	-0.43	-2.20	-0.80	22.29	34.97	36.27	-3.39	-27.32	-27.55	-10.78	6.51	-0.58	-0.36
		b*	1.29	-0.39	-0.95	0.75	-1.71	1.96	13.61	43.53	70.17	9.57	11.96	-28.00	-16.14	-3.12	-1.30
Average Measurement (Corrected)	C	L*	95.90	83.27	60.64	61.19	38.06	46.85	46.74	67.03	83.97	57.50	57.49	55.12	31.01	30.70	75.79
		a*	-0.14	-0.41	-0.34	-2.10	-0.74	22.14	34.70	35.98	-3.37	-27.02	-27.25	-10.54	6.56	-0.52	-0.26
		b*	1.27	-0.39	-0.95	0.74	-1.70	1.92	13.49	43.25	69.76	9.53	11.90	-27.84	-16.08	-3.10	-1.30
NPL Values	D	L*	96.00	84.61	61.72	62.28	38.11	47.79	47.01	68.35	85.36	58.56	58.75	55.98	30.59	29.85	76.25
		a*	-0.30	-0.30	-0.20	-1.98	-0.79	23.04	36.83	37.26	-4.21	-28.21	-28.59	-11.00	7.31	-0.80	-0.22
		b*	1.89	0.41	0.24	1.88	-0.61	3.04	15.59	46.04	72.66	11.18	13.81	-28.06	-16.68	-2.31	-0.04
A to B		dE*	0.239	0.341	0.095	0.106	0.320	0.260	0.955	0.511	0.111	0.575	0.166	0.423	0.126	0.181	0.304
B to C		dE*	0.788	0.700	0.541	0.546	0.383	0.465	0.539	0.687	0.794	0.601	0.600	0.593	0.338	0.332	0.648
B to D		dE*	0.910	1.047	1.334	1.281	1.140	1.410	2.719	2.804	2.712	1.916	2.249	0.418	1.218	1.445	1.275
C to D		dE*	0.640	1.563	1.618	1.582	1.090	1.721	3.002	3.337	3.321	2.294	2.647	1.007	1.043	1.197	1.336
Corrected + Uncertainty	E	L*	97.71	85.29	63.47	63.99	43.38	50.80	50.71	69.54	85.98	60.52	60.51	58.30	38.27	38.08	77.99
		a*	-0.04	-0.32	-0.28	-2.06	-0.65	24.43	38.00	37.28	-3.21	-24.99	-25.20	-9.85	8.94	-0.39	-0.18
		b*	1.46	-0.19	-0.75	0.85	-1.24	2.02	15.40	46.76	73.77	10.13	12.72	-26.23	-11.84	-1.89	-1.08
Corrected - Uncertainty	F	L*	94.09	81.25	57.82	58.40	32.74	42.89	42.77	64.51	81.96	54.48	54.47	51.93	23.75	23.32	73.58
		a*	-0.25	-0.50	-0.40	-2.14	-0.82	19.85	31.40	34.68	-3.53	-29.06	-29.31	-11.23	4.18	-0.65	-0.35
		b*	1.08	-0.59	-1.15	0.63	-2.16	1.81	11.58	39.75	65.76	8.92	11.07	-29.44	-20.32	-4.31	-1.51



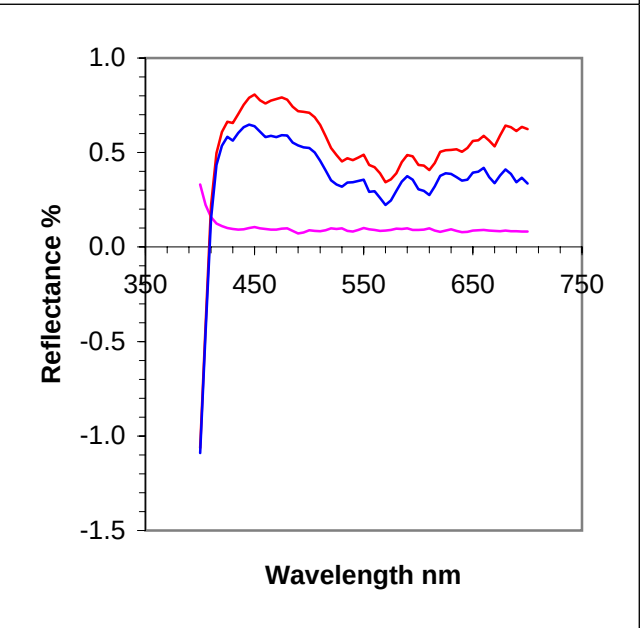
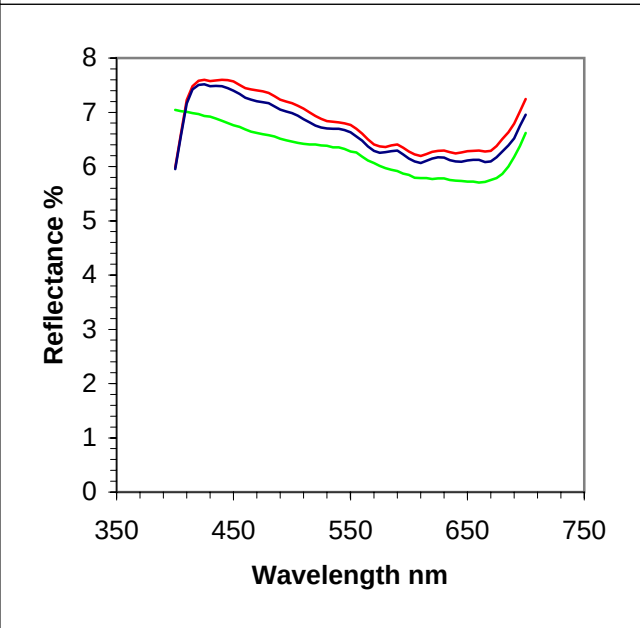




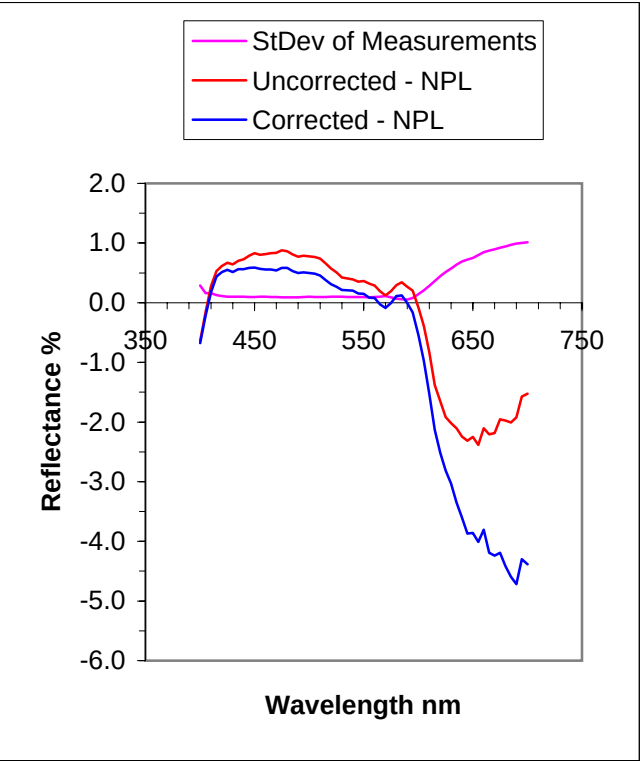
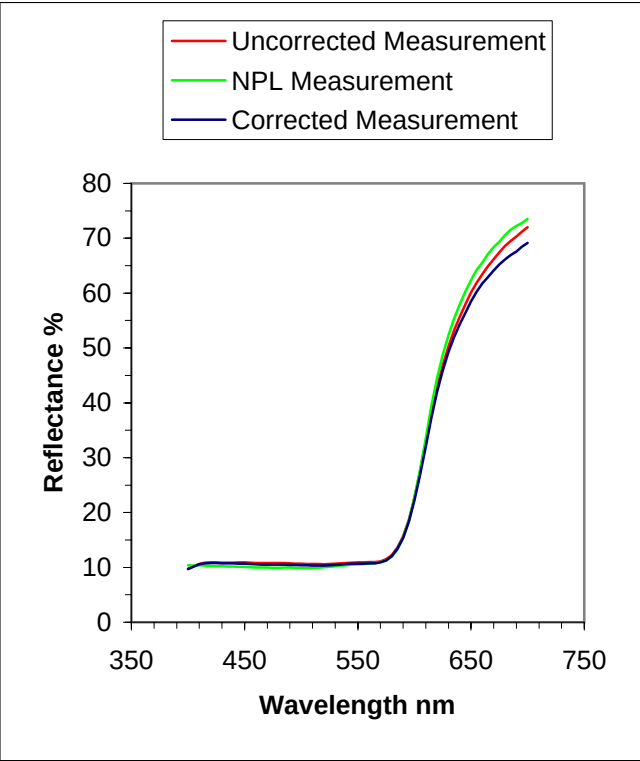
White
Matt



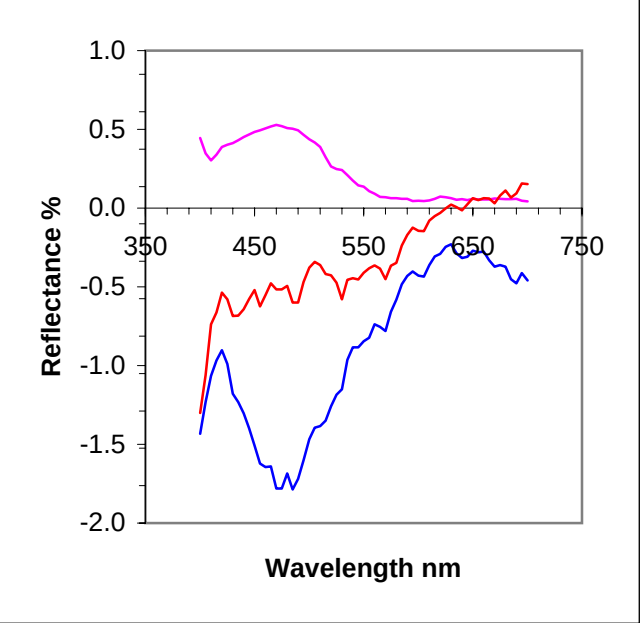
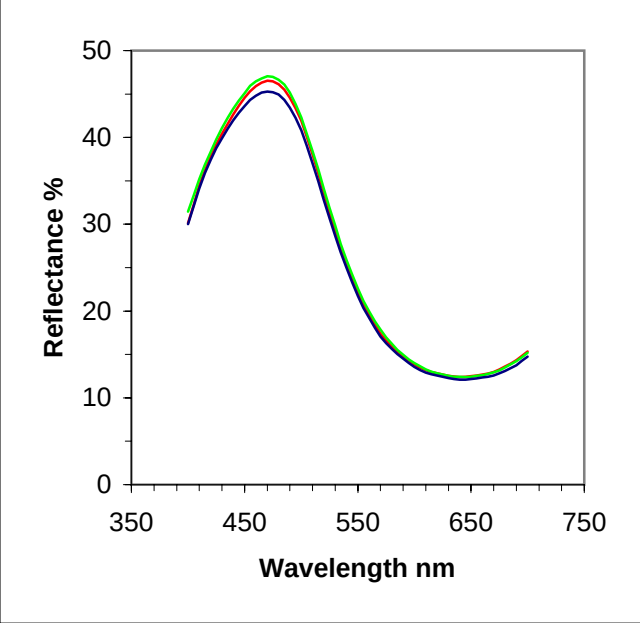
50 Grey
Matt



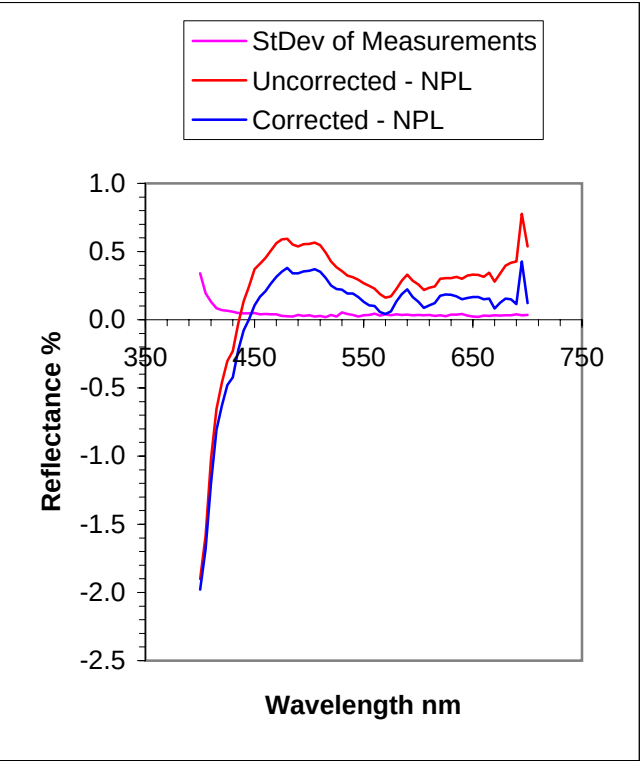
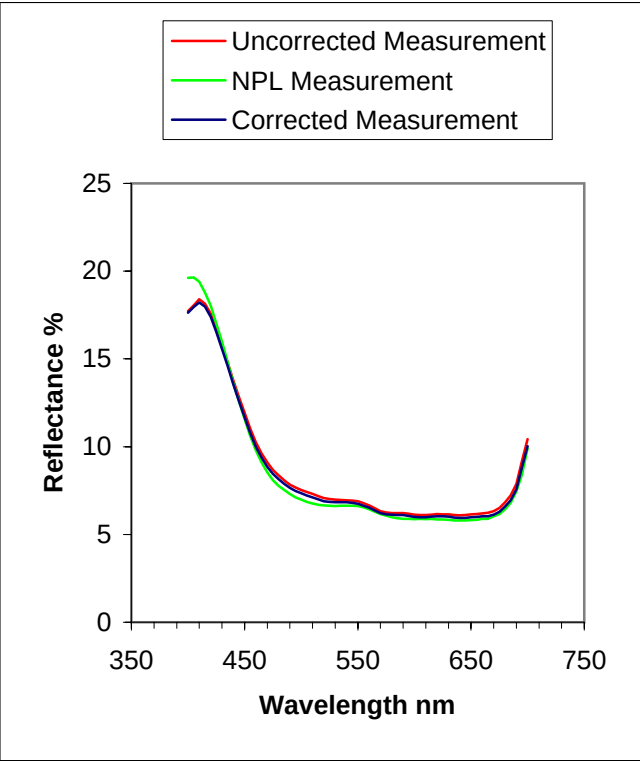
Black
Matt



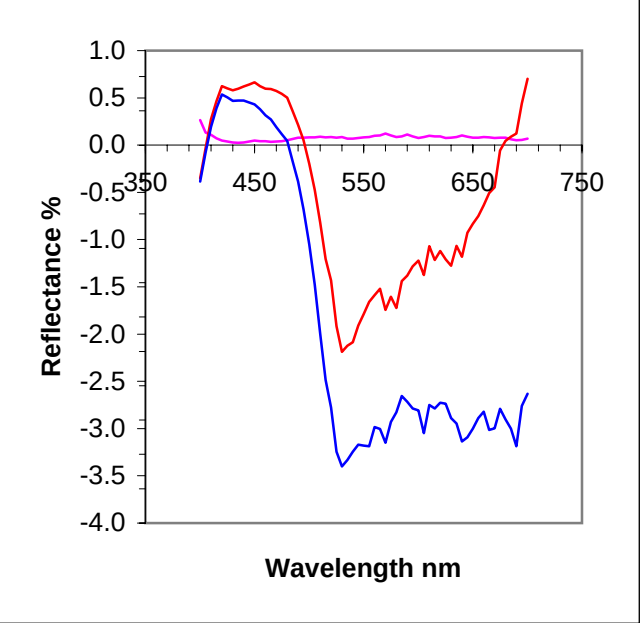
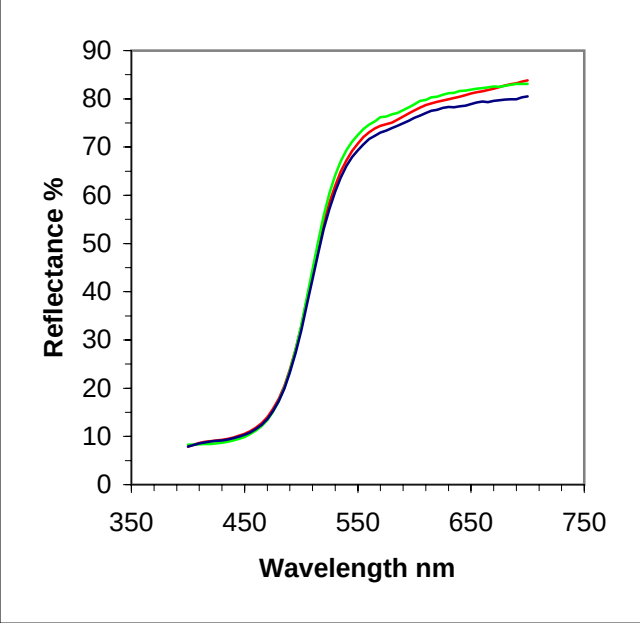
Red
Matt



Cyan
Matt



**Blue
Matt**



**Yellow
Matt**