RYETAGA

Technical Association of the Graphic Arts
Ryerson University Student Chapter

2016

RYETAGA

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RU:SUSTAINABLE CAMPUS CERTIFICATION PROGRAM

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THE PRESIDENTIAL ADDRESS

Dear TAGA,

It is a great pleasure to present to you, our 2016 Ryerson University Student Chapter journal. This is a compilation of efforts from a dedicated team of eight Graphic Communications Management (GCM) students at Ryerson University, in addition to the continuous support of our faculty, staff and sponsors. This year's journal has a core focus on colour and its applications.

We would like to give gracious thanks to our team, who have worked very diligently throughout this year to make this journal a success. Our faculty advisor, Scott Millward, has continually supported us and believed in us every step of the way. GCM has also provided us with many of the tools that have made this journal possible. Last but not least, we would like to show our gratitude to the Ryerson Communication & Design Society (RCDS) for supporting us throughout this journey making this trip and the entire process much easier on the team.

We are excited to share all the experiences we have had while creating and producing this journal as we head to the 68th Annual TAGA Conference in Memphis, Tennessee. We know that there are high expectations for us, and regardless of the outcome, we are proud of the hard work of everyone involved and appreciate the opportunity we have been given. We have gone on a journey, allowing us to grow in many ways to become more motivated, knowledgeable, understanding and inspired. This has been the experience of a lifetime, and it is our honour to share it with you.

Sincerely,

Diondra Filicetti & Jessica Tam
Your RyeTAGA Co-Presidents

A LETTER FROM THE FACULTY ADVISOR

Hello RyeTAGA!

After many months of hard work and dedication, you have produced a journal that is ready to be shared at the March 2015 TAGA Conference in Memphis, Tennessee.

We had a very successful membership drive this year, introducing the challenges and rewards of TAGA to more members of the GCM community. Our RyeTAGA calendar sales were strong this year and we were able to raise substantial funds to help support the production of the journal and your trip to Memphis.

Each article in this journal represents the thoughtful research of you and your peers, and you should be proud to have provided them with such a professional forum for their work.

Your time at Ryerson is valuable, challenging, and also short. This conference is a chance to strengthen relationships you may have forged in years past, and meet new contacts at other schools and in industry that may be enriching for you as you move forward with your careers. Make sure you take advantage of opportunities to connect, learn and share.

Congratulations on a job well done, and I hope that you enjoy this year's conference!

Sincerely,

Scott Millward, M.Sc., B.Tech
Ryerson TAGA Student Chapter Advisor

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EVALUATION OF SPOT COLOUR ACCURACY IN DIGITAL PRINTING WITH THE XEROX 700

By: Tabrina Loch-Williams & Beverly Bourke

ABSTRACT

This experiment allowed a connection between spot colours and the digital press. Often, digital presses are known to be incapable of printing PANTONE spot colours precisely and accurately. While this remains true, it disregards the fact that with certain measurements and modifications to the values, accurate CMYK versions of these PANTONE spot colours, can be outputted. With automatic and manual adjustments made through the FreeFlow Workflow, the Xerox 700 digital press is able to print a PANTONE spot colour simulation through the use of CMYK toners. By referencing the Photoshop L*a*b* values to the X-Rite Spectrodensitometer L*a*b* values of the print and doing manual adjustments through FreeFlow's Spot Color Editor, each PANTONE spot colour sample resulted in a Delta E (ΔE) of 2.0 or less, with an overall average of 1.21. Accurate colour reproduction determines satisfaction from a client's point of view, and with the trend to utilize more digital printing in the future; developing methods to reproduce spot colours without special inks is crucial to industry growth.

INTRODUCTION

This experiment was conducted in order to determine how accurately the Xerox 700 digital press could print various PANTONE spot colours. Digital presses are unable to print spot colours using special inks; however, this experiment was carried out to show the various ways spot colours can be printed accurately through the use of CMYK toners.

The goal of this experiment is to prove that if adjustments are made to the colour upon output – whether through an automatic workflow or manually – then, it is possible to accurately print and match PANTONE spot colours on the Xerox 700 without the use of PANTONE inks. It is common industry knowledge that reproduction of spot colours through CMYK inks can be difficult at best, and that it is not only important to "choose a colour printer with an as large-as-possible colour gamut", but also "the colour

printer needs a RIP that can render colours in an efficient and accurate way" (Digital Dots Ltd., 2007). This statement essentially represents the main idea behind this particular experiment as the Xerox FreeFlow RIP has a gamut that makes spot colour reproduction possible, but also allows for conversion of these colours.

To achieve accurate results, the first steps include grasping the idea of the four methods used to print spot colours on a digital press. These methods include conversions in application (for example, Photoshop or Illustrator), enable spot colour in the Xerox FreeFlow colour management workflow, disable spot colour in FreeFlow, and manual adjustments in the Spot Color Editor ("ring-around") (Xerox, 2009). Conversions in application involve using the PANTONE Bridge Library in Photoshop to allocate CMYK values to a desired PANTONE spot colour.

By selecting enable spot colour in the Xerox FreeFlow workflow, this allows for a specific PANTONE swatch to be sent and looked up in Xerox FreeFlow's PANTONE library and print according to the CMYK "recipe" denoted in that library. By selecting disable spot colour, the swatch is then converted to CMYK within the FreeFlow RIP without concern for colour matching through the PANTONE library. Lastly, manually adjusting the CMYK values also occurs within Xerox FreeFlow. The "ring-around" shows similar colour patches that may be more accurate to the desired PANTONE swatch within Xerox FreeFlow; however, this does not guarantee accurate results. In the custom dialogue box, the user is able to manually alter CMYK values in order to determine what combination produces the most accurate representation of the desired PANTONE swatch. These CMYK values can then be saved in the Custom folder, so that the user can retrieve them when necessary. Specifically for this experiment,

ten swatches were chosen in Photoshop from the PANTONE Solid Coated Library, which is also used in the Xerox FreeFlow system. PANTONE Solid Coated Library was used in the experiment due to GRACoL's 2006 specifications, which were developed for coated paper, and was also a fair simulation of the Xerox gamut, albeit with some variations.

Outputting a PDF from Photoshop, however, would not allow for the spot colours to be shown, even with a PDF format designed for spot colour output. The only solution was to create the same PANTONE spot colour swatches in Adobe Illustrator and export a PDF from there. However, this posed another problem as Adobe Illustrator only contains the PANTONE+ Solid Coated Library, which would result in L*a*b* variations from the original PANTONE Solid Coated Library used in FreeFlow.

To keep consistency across all software platforms used for this experiment, the L*a*b*

values were recorded based on the PANTONE Solid Coated Library displayed in Adobe Photoshop. The same swatches were then altered in Illustrator according to the Photoshop L*a*b* values in order to remain consistent with PANTONE Solid Coated Library values. This was possible since FreeFlow recognizes the PANTONE colours by the reference number assigned to the swatch, rather than by the assigned L*a*b* values. This means that even if a swatch was assigned with a completely wrong colour information, it would still print out correctly to the CMYK conversion applied to that PANTONE swatch in FreeFlow with spot colour enabled. This also allowed for consistency with spot colour disabled because the same L*a*b* values associated with the PANTONE colour in the FreeFlow library are being used when printing without this reference, allowing for accurate comparison between how spot colours

are handled through the enable and disable spot colour portions of the workflow.

The goal of this experiment was to identify the most accurate way to print a CMYK version of a PANTONE spot colour on a digital press. The question of whether or not a digital press can produce a spot colour with a colour match of ΔE of 2.0 or less of its original Photoshop L*a*b* values. The projected outcome was that some Photoshop L*a*b* PANTONE swatches and the X-Rite Spectrodensitometer L*a*b* readings would be within the ΔE of 2.0 after the first set of unadjusted measurements. It was expected that adjustments would be required for some swatches, specifically the more vibrant colours, since uncoated paper was used to conduct the experiments, which would reduce the vibrancy of colours from the lack of brightness from the coating. In printing, the universal standard for

ΔE values are 1.0 or less for no difference, 1.0 to 2.0 for a small difference unperceivable to the untrained eye, 2.0 to 3.5 for a small difference that can be detected by the untrained eye, 3.5 to 5.0 for an obvious difference, and more than 6.0 for a very obvious difference (EFI).

EXPERIMENTAL SETUP

EQUIPMENT

- Xerox 700 digital press
- Xerox FreeFlow workflow
- Adobe Photoshop CS6
- Adobe Illustrator CS6
- CHROMiX ColorThink
- Bruce Lindbloom Color Difference Calculator
- X-Rite 500 Series Spectrodensitometer

MATERIAL

- White Xerographic copy paper, 8-1/2" x 11", 92 brightness, 20 lbs./10 M/75 g/m^2

EQUATION

$$\Delta E_{ab} = \sqrt{\left(L^*_2 - L^*_1\right)^2 + \left(a^*_2 - a^*_1\right)^2 + \left(b^*_2 - b^*_1\right)^2}$$

PROCEDURE

1. Design the test form with ten PANTONE+ Solid Coated colours in Illustrator, all within the GRACoL 2006 colour gamut.
2. Change the L*a*b* for each spot colour in Illustrator to the reference values in Photoshop, using the PANTONE Solid Coated swatch library.
3. Export the Illustrator document to a PDF/X-4.
4. Run the test form two times on the Xerox 700 using the Xerox FreeFlow workflow, one copy with spot colour enabled and one with spot colour disabled.
5. Using the X-Rite Spectrodensitometer, measure the L*a*b* values for each spot colour. Do this process for both the spot colour enabled copy and the spot colour disabled copy. Make sure to have another sheet of paper underneath them when measuring; otherwise, the measuring surface can alter your readings.
6. Using the L*a*b* references values from Photoshop for the PANTONE Solid Coated colour library, calculate the ΔE_{ab} for each test patch on each copy of the test form. Make sure to use the 1976 ΔE formula.
7. Within the FreeFlow workflow, adjust the CMYK values for any spot colours that are not within a ΔE_{ab} tolerance of 2.0 or less. As a starting point, use the CMYK values given for each spot colour in the PANTONE Solid Coated library in Photoshop (make sure the working CMYK gamut is set to GRACoL 2006).
8. Continue measuring with the Spectrodensitometer and making adjustments until all the PANTONE swatches are within tolerance.

The test was conducted by, first, designing the test form in Illustrator, and then exporting a PDF that would allow for spot colour printing. This test form was printed on 8-1/2" x 11" paper on the Xerox 700 digital press in the basement of the Heidelberg building at Ryerson University. One sample was printed using the Xerox FreeFlow spot colour enabled workflow and one was

printed spot colour disabled. L*a*b* measurements were taken using the X-Rite Spectrodensitometer of both samples for all colours. For any colours that needed adjustments to be within tolerance of a ΔE_{ab} of 2.0 or under, the CMYK adjustments were made in the Spot Color List in the FreeFlow workflow until the correct ΔE_{ab} was achieved. Each colour was adjusted individually and measured until the correct ΔE_{ab} was obtained. Afterwards, another spot colour was selected and the same process was repeated. All the measurements were taken in the basement of the Heidelberg building, at the desk where the FreeFlow workflow is contained.

RESULTS

FIGURE 1

Comparing the ΔE_{ab} values of spot colour disabled, enabled and adjusted.

ΔE_{ab} COMPARISON BETWEEN SPOT COLOUR DISABLED, ENABLED, AND ADJUSTED VALUES
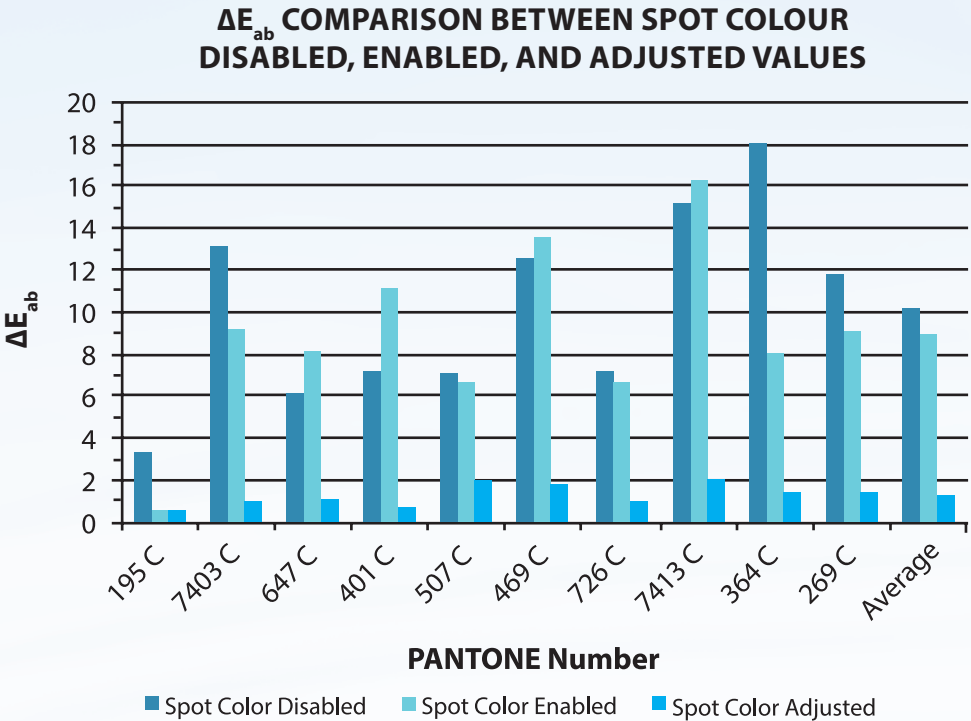
TABLE 1 & 2

Reference, spot colour enabled and disabled values of PANTONE spot colours and their ΔE_{ab} before and after adjustments.

Reference Values vs. Spot Colour Enabled and Disabled Values (before adjustments)					
PANTONE No.	L*a*b* Reference Values	Spot Colour Enabled L*a*b* Values	ΔE_{ab}	Spot Colour Disabled L*a*b* Values	ΔE_{ab}
195 C	L* = 31 a* = 33 b* = 7	L* = 30.39 a* = 32.97 b* = 6.82	0.64	L* = 30.04 a* = 34.36 b* = 5.21	3.33
7403 C	L* = 84 a* = 3 b* = 45	L* = 77.31 a* = 4.99 b* = 39.01	9.20	L* = 77.27 a* = 6.47 b* = 34.40	13.10
647 C	L* = 35 a* = -6 b* = -34	L* = 33.49 a* = -0.45 b* = -28.17	8.20	L* = 33.83 a* = -0.96 b* = -30.76	6.10
401 C	L* = 73 a* = 1 b* = 5	L* = 64.59 a* = 6.36 b* = 0.14	11.09	L* = 66.54 a* = 3.22 b* = 2.87	7.16
507 C	L* = 68 a* = 24 b* = -1	L* = 61.84 a* = 25.53 b* = -3.06	6.67	L* = 62.15 a* = 27.65 b* = -2.26	7.01
469 C	L* = 28 a* = 18 b* = 24	L* = 33.21 a* = 11.68 b* = 13.19	13.56	L* = 29.51 a* = 16.19 b* = 11.67	12.55
726 C	L* = 84 a* = 7 b* = 17	L* = 78.31 a* = 6.55 b* = 13.47	6.71	L* = 77.98 a* = 6.61 b* = 13.14	7.16
7413 C	L* = 61 a* = 34 b* = 60	L* = 57.17 a* = 30.25 b* = 44.58	16.32	L* = 57.22 a* = 30.22 b* = 45.79	15.18
364 C	L* = 45 a* = -29 b* = 32	L* = 37.87 a* = -29.01 b* = 28.19	8.08	L* = 40.34 a* = 19.92 b* = 17.01	10.08
269 C	L* = 25 a* = 23 b* = -29	L* = 26.78 a* = 17.10 b* = -22.30	9.10	L* = 26.73 a* = 13.62 b* = -220	11.83
Average			8.96		9.35

Reference Values vs. Spot Colour Enabled Values (after adjustments)

PANTONE No.	L*a*b* Reference Values	Final L*a*b* Values	ΔE_{ab}	Starting CMYK Values	Adjusted CMYK Values
195 C	L* = 31 a* = 33 b* = 7	L* = 30.39 a* = 32.97 b* = 6.82	0.64	C = 50 M = 97 Y = 86 K = 15	C = 50 M = 97 Y = 86 K = 15
7403 C	L* = 84 a* = 3 b* = 45	L* = 83.19 a* = 2.51 b* = 44.56	1.04	C = 7 M = 20 Y = 65 K = 0	C = 0 M = 12 Y = 63 K = 0
647 C	L* = 35 a* = -6 b* = -34	L* = 33.23 a* = -5.61 b* = -33.99	1.18	C = 96 M = 63 Y = 19 K = 4	C = 88 M = 54 Y = 24 K = 8
401 C	L* = 73 a* = 1 b* = 5	L* = 72.43 a* = 0.87 b* = 5.40	0.71	C = 30 M = 32 Y = 28 K = 0	C = 26 M = 22 Y = 30 K = 1
507 C	L* = 68 a* = 24 b* = -1	L* = 67.57 a* = 25.03 b* = -2.64	1.98	C = 16 M = 49 Y = 20 K = 1	C = 10 M = 41 Y = 18 K = 0
469 C	L* = 28 a* = 18 b* = 24	L* = 29.05 a* = 19.16 b* = 23.20	13.56	C = 55 M = 77 Y = 93 K = 30	C = 0 M = 71 Y = 100 K = 51
726 C	L* = 84 a* = 7 b* = 17	L* = 84.41 a* = 6.69 b* = 18.29	6.71	C = 7 M = 20 Y = 28 K = 0	C = 2 M = 17 Y = 30 K = 0
7413 C	L* = 61 a* = 34 b* = 60	L* = 61.28 a* = 33.08 b* = 58.26	16.32	C = 11 M = 60 Y = 96 K = 0	C = 1 M = 54 Y = 99 K = 0
364 C	L* = 45 a* = -29 b* = 32	L* = 45.12 a* = -28.48 b* = 30.70	8.08	C = 83 M = 38 Y = 100 K = 7	C = 75 M = 26 Y = 99 K = 10
269 C	L* = 25 a* = 23 b* = -29	L* = 24.71 a* = 23.25 b* = -29.05	9.10	C = 82 M = 92 Y = 37 K = 5	C = 84 M = 97 Y = 21 K = 0
Average			5.93		

ANALYSIS

According to Howard (2012), other Xerox digital presses, specifically, the Xerox DocuColor 2060, have been able to be colour managed so that they are able to reproduce PANTONE spot colours in a more accurate fashion. Although this colour management was done with an profile using a GRACoL target sheet rather than a RIP system, it still shows that spot colour reproduction with just CMYK toner is becoming more and more possible as new technology is developed. Howard (2009) also experienced similar results where overall, with just applying an overall colour adjustment (spot colour enable in the case of this experiment), it was possible to get a lower ΔE_{ab} average value, but still not one that is consistent with an unperceivable colour difference.

The data shows that using neither the spot colour enabled or disabled workflows on the Xerox 700 will result in an accurate colour match without any adjustments. The only excep-

tion to this would be PANTONE 195 C swatch, as it was under ΔE_{ab} of 2.0 with the spot colour workflow enabled without any manual adjustments. As well, the data shows that the spot colour disabled workflow is more likely to result in a higher overall ΔE_{ab} value than the spot colour enabled workflow. This is consistent with expectations for the FreeFlow workflow, since the point of having the spot colour enabled workflow would be to create closer colour matches than if the PANTONE colours were just processed through the regular CMYK workflow. The variance between the spot colour enabled and disabled workflows is not large; therefore, it is possible that with a different set of PANTONE samples, the results could be different.

The main conclusion that can be drawn from this test is that because the colour match is dependent on factors such as the paper, inks, etc., it will most likely be necessary to adjust the CMYK values in the enabled

workflow to create the desired ΔE_{ab} colour match.

The default CMYK values that the FreeFlow workflow retrieves from the reference PANTONE Solid Coated swatch book installed in the system have to be altered to create a colour match within tolerance. It is also important to note that for any of the spot colours to be reduced to a ΔE_{ab} of 2.0, they must be within the GRACoL 2006 gamut, preferably not along the edge of the gamut. This is because the Xerox 700 is certified by the IDEAlliance to print to GRACoL specifications, although the gamuts are not exactly the same (Ramsey, 2011). This is why it is best to keep the spot colours more to the center of the GRACoL gamut as possible. This was tested for this experiment by using ColorThink to analyze the GRACoL 2006 gamut with the spot colour patches that were being used for this test. The original test sample included spot colours that were along the very edge of the GRACoL gamut, so these colours were changed to swatches that were within the gamut. It would be recommended to printers using the FreeFlow workflow with the Xerox 700 to check the spot colours used in any files they received from clients using this method.

FIGURE 2 & 3

PANTONE spot colours from the original test form.
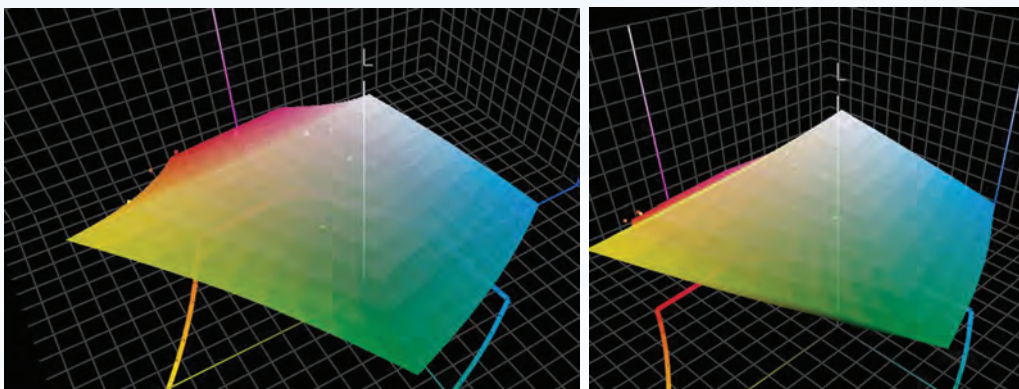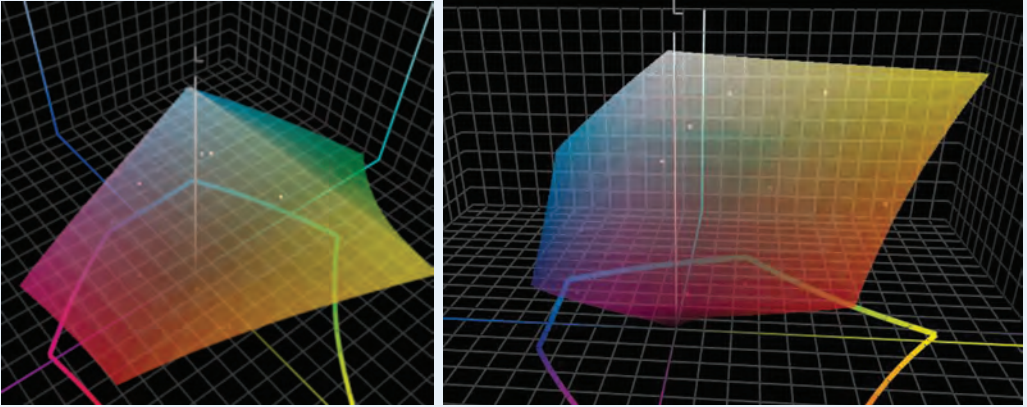
FIGURE 4 & 5

PANTONE spot colours from the final test form, all colors in gamut of GRACoL 2006.

Overall, it is possible to achieve accurate spot colour representation on the Xerox 700 if you adhere to the gamut requirements. Clearly, the CMYK values that achieved a ΔE_{ab} of 2.0 or less are only representative of the conditions this test was done under, so specifically for the paper used, the digital press used, inks used, etc. (Typhoon, 2011).

Once adjustments are made in the FreeFlow Spot Colour Editor, they can be saved into a custom folder, so printers can return to those values if the same colours are used for another job using the same materials. The results confirmed the assumption that

it would be possible to have an accurate colour match for spot colours on the Xerox 700 digital press. This is because all the CMYK values of the spot colour could be adjusted, resulting in a ΔE_{ab} less than 2.0. On the other hand, the experiment did not prove the assumption that the ΔE_{ab} would be under 2.0 through the spot colour enabled workflow without any adjustments. Possible errors that could have occurred during the testing of the PANTONE colours are human errors, such as reading the L*a*b* values incorrectly or not making measurements under the same environmental conditions. Some other errors could include issues with the

materials. The experiment was carried out over the span of approximately three weeks; during that time, there was an issue with the Xerox 700 digital press used in the experiment, which may have altered some variables slightly after the press was fixed. Although the same paper was maintained throughout the experiment, each batch of paper is still slightly different; therefore, giving the chance for altered results.

CONCLUSION

A quantitative approach was used throughout this experiment, which was carried out to limit subjectivity of colour accuracy. Colourimetric colour (CIELAB) was used in order to provide an objective measurement to determine accurate colour. Contrary to the expected outcome, all of the original PANTONE Solid Coated swatches required CMYK adjustments in order to achieve a ΔE_{ab} tolerance of 2.0, except PANTONE 195 C. The expectation that all spot colours would be reproducible given accurate CMYK adjustments through the spot colour enabled workflow turned out to be unattainable.

Digital printing is quickly becoming the way of the future; therefore, it is crucial to adapt digital presses to the spot colour reproduction capabilities of an offset press.

A problem that occurred was the inability to achieve a ΔE_{ab} of 2.0 between the Adobe Photoshop L*a*b* values and the print's X-Rite Spectrodensitometer L*a*b* values of certain PANTONE swatches. The five PANTONE swatches that would not achieve the desired ΔE_{ab} tolerance were 179 C, 115 C, 639 C, 158 C, and 359 C. To allocate this problem, these PANTONE spot colours were placed in CHROMiX ColorThink to assess their location in relation to GRACoL's gamut. Unsurprisingly, these spot colours were located just on the outside of GRACoL's 3-D

gamut volume. Assuming that the GRACoL colour gamut is similar to the Xerox colour gamut, these unattainable PANTONE spot colours were changed to ones within gamut. This concluded that Adobe Photoshop is not accurate when determining the likelihood of a spot colour being reproducible within GRACoL's gamut. When viewing a PANTONE swatch in Adobe Photoshop, the gamut warning feature is not a precise method in determining its ability to print within a specific colour specification.

By selecting "Enabled" in Xerox FreeFlow, this resulted in a smaller colour difference when comparing Adobe Photoshop's L*a*b* values of PANTONE swatches to the final print's X-Rite Spectrodensitometer L*a*b* values. While having an average ΔE_{ab} of only 8.96 and still not being within the required ΔE_{ab} of 2.0, it produced a much better result than the disable spot colour option, which resulted in a ΔE_{ab} average of 10.15. It is crucial to note that neither the enabled or disabled setting will provide the user with an acceptable and useable print, because of the ΔE_{ab} values being greater than 6.0.

An essential factor that must be kept in mind is that this experiment was conducted specifically on the Xerox 700 digital press located in the basement level of the School of Graphic Communications Management. If accurate spot colour reproduction is required, then the desired colours must be manually adjusted in the Xerox FreeFlow workflow for

each press. Every press has slight variations in their capabilities and accuracies. Paper is another factor that will affect the final print and its accuracy to the Adobe Photoshop L*a*b* values. The paper used in this experiment will result in different outcomes than substrates with variations in opacity, coatings, and caliper. Being able to adjust the CMYK values in Xerox FreeFlow makes the spot colour workflow useful because those values can be saved and stored for whenever that type of paper is used in the future.

ACKNOWLEDGEMENTS

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QUANTIFICATION & MEASUREMENT OF OBAs & UV FLUORESCENCE IN PAPER

By: Melissa Karjanmaa

ABSTRACT

With regards to colour accuracy and colour measurement devices, it is newly understood that Optical Brightening Agents (OBAs) and UV fluorescence in paper can have an effect visually and numerically on the colour of paper and of a printed image. By measuring a sample paper under the newly defined M1 and M2 measurement conditions, the presence of these OBAs can be pinpointed and quantified with actual values, establishing the severity of the chemicals' content within the sample. To carry out the investigation, six different paper samples were measured with an X-Rite eXact Spectropho-tometer to collect their spectral reflectance and L*a*b* data. This spectral reflectance data of both measurement modes was then graphed to depict a visual representation of the OBA content, where results showed that proofing paper contained the least amount of OBAs and uncoated paper contained the most. The collected data was also used to calculate Δb* and ΔB to put a number to the visual representation seen in the graphs, where different results were yielded for each calculation. Overall, as the Δb* increased, the ΔB increased linearly. From this, it can be concluded that it is in fact possible to measure and quantify the amount of OBAs present in a given paper to some degree. However, the accuracy of the methods could be improved until there is one consistent standard across the industry.

The purpose of this project is to examine the methods of quantifying and measuring OBAs and UV fluorescence in paper. There are a variety of proposed methods to complete the examination; however, the focus will be on measuring the spectral reflectance and L*a*b* values of samples under M1 and M2 measurement modes, and using this data to calculate Δb* and ΔB.

When a printed product is examined under different light sources, the colour accuracy of the print can change. One cause of this change can revolve around the substrate itself, where different papers react differently under various light sources (Kraushaar, 2013). This occurs due to the OBAs chemically present in a paper, which are meant to cheaply provide brighter, whiter paper to customers as opposed to the more expensive bleached substrates (Pady, 2008). These chemicals, however, cause the paper itself to absorb invisible UV light and reflect it as blue light in the visible spectrum, resulting in negative effects such as metamerism (Wales, 2008). As a varied light source can cause metameric effects on a printed sample with the human eye, a similar result occurs with varying light sources in measurement devices. Older measurement devices such as spectrophotometers use an unspecified light source to complete readings, giving the user no predictability in terms of results since the light source changes from device to device (O'Connor, 2011).

In order to account for the variance, new measurement conditions were established, where M0 is the legacy condition for all older devices with light sources that are not necessarily consistent (O'Connor, 2011). M1

mode takes its measurements with a light source that matches the CIE Illuminant D50 and includes UV light (O'Connor, 2011). M2 mode takes its measurements with a defined UV light exclusion as established by ISO 13655 (Sharma, 2014).

The spectral reflectance data taken from a sample under both modes provides a visual representation of a substrate's OBA content. In order to quantify this content, Δb^* and ΔB can be calculated. Δb^* uses the difference in b^* results from the $L^*a^*b^*$ values of a substrate under both measurement modes to demonstrate this difference, which works due to the fact that the UV fluorescence from OBAs appears in the blue area of the visible spectrum (Wales, 2013). ΔB calculates the difference in brightness as established in ISO 2470-2, using a more complex equation (Kraushaar, 2013).

It is predicted that in the experiment, the Δb^* and ΔB values will be relatively similar, and will both effectively quantify the amount of OBAs present in the samples. Additionally, the OBA free paper as well as proofing papers will contain the least amount OBAs, with the OBA free sample containing none at all. It is also predicted that the coated substrates will have the highest amount of OBAs, due to the fact that these substrates already contain a number of additives.

To perform the test, six different paper samples were selected and measured 10 times total using an X-Rite eXact Spectrophotomter under M1 and M2 modes (five measurements for each mode). This was done to collect spectral reflectance and $L^*a^*b^*$ data for each substrate under both modes, so the findings could be graphed and the Δb^* and ΔB could be calculated.

EXPERIMENTAL SETUP

EQUIPMENT

- X-Rite eXact Spectrophotometer

MATERIAL

- ORIS PearlPROOF Select White, 210 g/m^2
- ORIS PearlPROOF Publication (OBA Free), 240 g/m^2
- Roland Opaque 26x40, 219M
- Supreme Gloss Offset 20x29, 122M
- Kodak MatchPrint Proofing Paper, 44"x100" Roll
- Williamsburg Offset 29x35, 110M

EQUATION

$$\Delta b^* = (b^*_{Reference} - b^*_{Sample})$$

$$\Delta B = R_{457,D65} - R_{457,UVX}$$

Where R$_{457}$ represents a set of constants

TABLE 1: R457 CONSTANTS

WAVELENGTH	CONSTANT
400 nm	1
410 nm	6.7
420 nm	18.2
430 nm	34.5
440 nm	57.6
450 nm	82.5
460 nm	100
470 nm	88.7
480 nm	53.1
490 nm	20.3
500 nm	5.6
510 nm	0.3

PROCEDURE

The X-Rite eXact Spectrophotometer was calibrated to function under the M1 measurement mode, then the spectral reflectance and L*a*b* values of ORIS PearlPROOF Select White sample was measured a total of five times. This process was repeated for the same sample under the M2 measurement mode, ensuring that the device was calibrated for the new mode. The same data was collected for the remaining five substrates and entered into an Excel spreadsheet, where each samples data under both measurement modes was averaged. The averaged data was then used to graph the spectral reflectance of both measurement modes for each sample and to calculate Δb* as well as ΔB. Finally, the M1 mode a* and b* values were graphed, as well as a comparison of the calculated Δb* and ΔB results.

1. Calibrate the X-Rite eXact Spectrophotometer.
2. Measure the spectral reflectance of the ORIS PearlPROOF Select White paper using the spectrophotometer under the M1 mode. Repeat this measurement for a total of five times.
3. Measure the L*a*b* values of the ORIS PearlPROOF Select White under the M1 mode five times.
4. Change the spectrophotometer into M2 measurement mode, recalibrating as instructed by the device.
5. Repeat steps 2 and 3, measuring the spectral reflectance data and L*a*b* values of the ORIS PearlPROOF Select White paper under the M2 measurement mode.
6. Repeat steps 2-5 for the remaining test substrates.
7. Calculate the Δb* and the ΔB for each test substrate using the formulas provided under "Equation."

RESULTS

FIGURE 1: SPECTRAL REFLECTANCE GRAPHS

FIGURE 1.1: ORIS PEARLPROOF PUBLICATION

The data shows that the ORIS PearlPROOF Publication paper has little reflection difference between the M1 and M2 measurements.

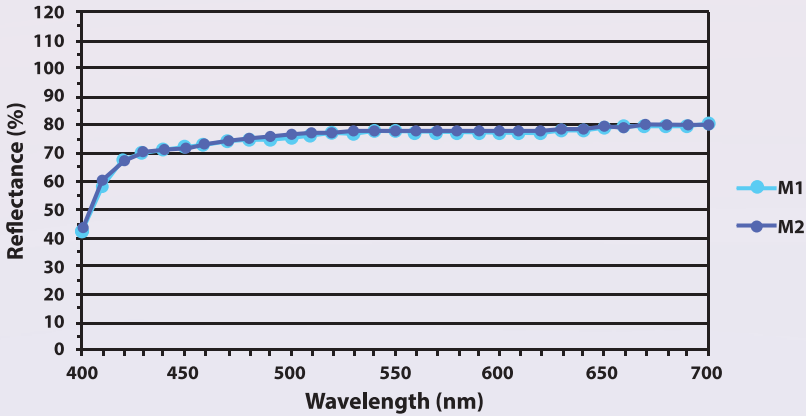**ORIS PEARLPROOF PUBLICATION**

FIGURE 1.2: KODAK MATCHPRINT

The data shows that the Kodak MatchPrint proofing paper has a slight amount of reflection difference between the M1 and M2 measurements in approximately the 420 – 460 nm area of the spectrum.
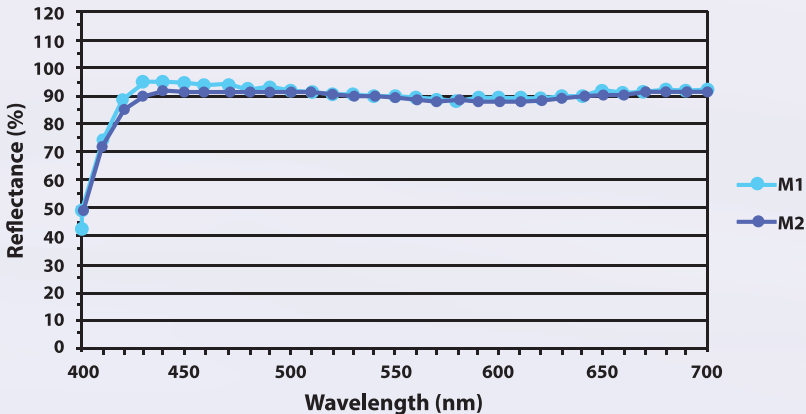
KODAK MATCHPRINT

FIGURE 1.3: ORIS PEARPROOF WHITE

The data shows that the ORIS PearlPROOF White paper has a reflection difference between the M1 and M2 measurements in the 410 – 500 nm area of the spectrum.
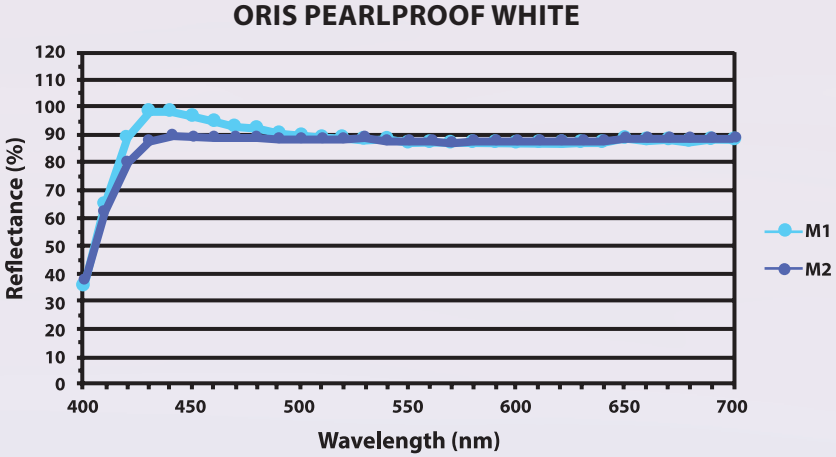
ORIS PEARLPROOF WHITE

FIGURE 1.4: SUPREME GLOSS OFFSET

The data shows that the Supreme Gloss Offset paper has a reflection difference between the M1 and M2 measurements in approximately the 410 – 500 nm area of the spectrum.
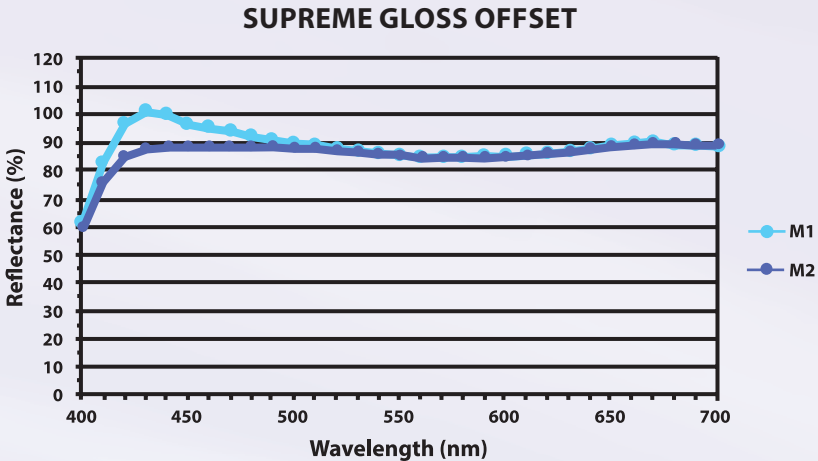
SUPREME GLOSS OFFSET

FIGURE 1.5: WILLIAMSBURG OFFSET

The data shows that the Williamsburg Offset paper has a very high reflection, with difference between the M1 and M2 measurements in approximately the 410 – 520 nm area of the spectrum.
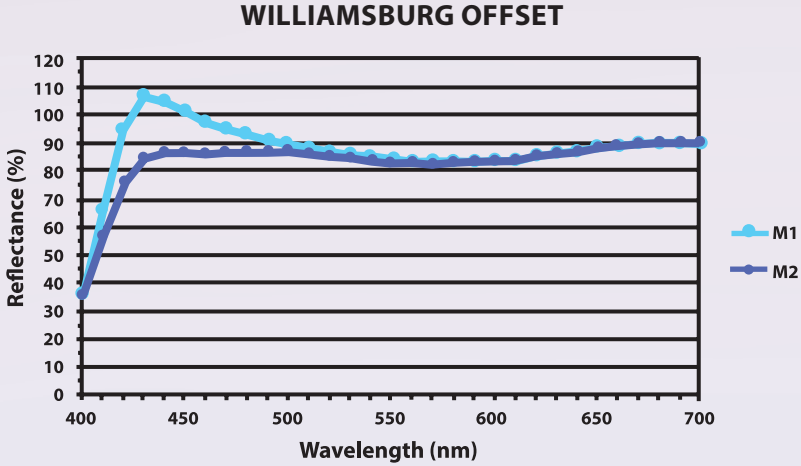
WILLIAMSBURG OFFSET

FIGURE 1.6: ROLAND OPAQUE

The data shows that the Roland Opaque paper has a very high reflection difference between the M1 and M2 measurements in approximately the 410 – 520 nm area of the spectrum.
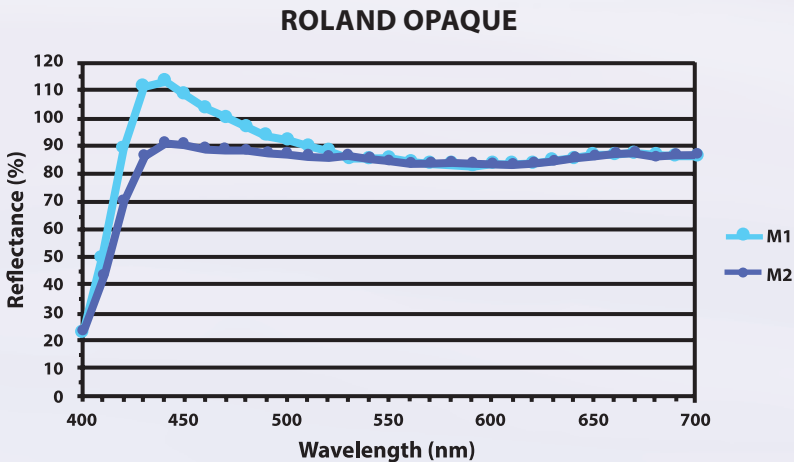
ROLAND OPAQUE

FIGURE 2: Δb* & ΔB

FIGURE 2.1: Δb* VALUES, ΔB VALUES & DIFFERENCES

Figure 2.1 displays the Δb* and the ΔB results calculated from the M1 and M2 measurements of each test substrate. It is clear that the tabulated results demonstrate the visual differences seen in each of the spectral reflectance graphs, with the largest difference being the Δb* and ΔB of the Roland Opaque sample, and the most minimal difference being in the ORIS PearlPROOF Publication. Additionally, it shows that the difference between the Δb* and ΔB values increases as the values themselves increase.

SUBSTRATE	Δb*	ΔB*	DIFFERENCES
PearlPROOF Publication	0.058	0.639	0.581
Kodak MatchPrint	1.374	1.970	0.595
PearlPROOF White	3.993	5.269	1.277
Supreme Gloss	4.716	6.810	2.094
Williamsburg Offset	7.864	11.702	3.838
Roland Opaque	9.643	14.832	5.189
Trendline Equation	Y = 1.4963x + 0.0246		

FIGURE 2.2: FOGRA OBA CLASSIFICATION

Levels of OBA as established by Kraushaar (2013).

OBA AMOUNT	DESCRIPTION
$0 \leq \Delta B < 4$	Faint
$4 \leq \Delta B < 8$	Low
$8 \leq \Delta B < 14$	Moderate
$14 \leq \Delta B < 25$	High

FIGURE 2.3: Δb* & ΔB GRAPH

The graph shows a comparison between the calculated values of Δb* and ΔB; there is a clear correlation between both values, where as the Δb* increases, the ΔB does as well.
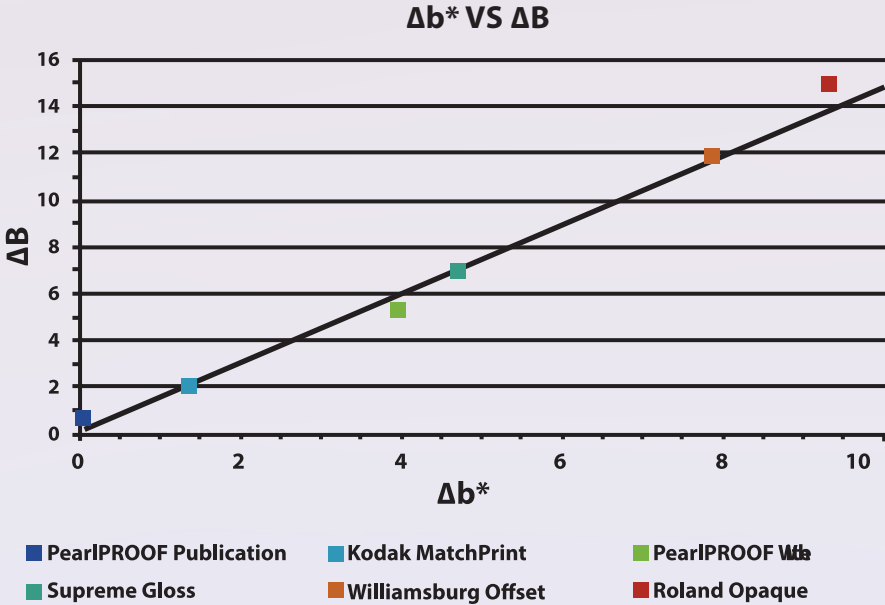
Δb* VS ΔB

Legend:
- PearlPROOF Publication
- Kodak MatchPrint
- PearlPROOF White
- Supreme Gloss
- Williamsburg Offset
- Roland Opaque

FIGURE 3: UV INCLUDED (M1) a* & b*

FIGURE 3.1: AVERAGE a* & b* VALUES

Averages of a* and b* values for each substrate.

MATERIAL	a*	b*
PearlPROOF Publication	-0.65562	4.02684
Kodak MatchPrint	-0.01916	-2.18182
PearlPROOF White	0.79994	-4.14606
Supreme Gloss	1.417	-6.32706
Williamsburg Offset	2.38642	-8.6249
Roland Opaque	2.01206	-11.5888

FIGURE 3.2: UV INCLUDED a* & b*

The graph demonstrates the a* and b* values of the UV included (M1) L*a*b* measurements. It is evident that there is slight trend between the a* and b* values; as the b* value becomes more negative, the a* value increases and vice versa.

UV INCLUDED a* & b*

- ■ PearlPROOF Publication
- ■ Supreme Gloss
- ■ Kodak MatchPrint
- ■ Williamsburg Offset
- ■ PearlPROOF White
- ■ Roland Opaque
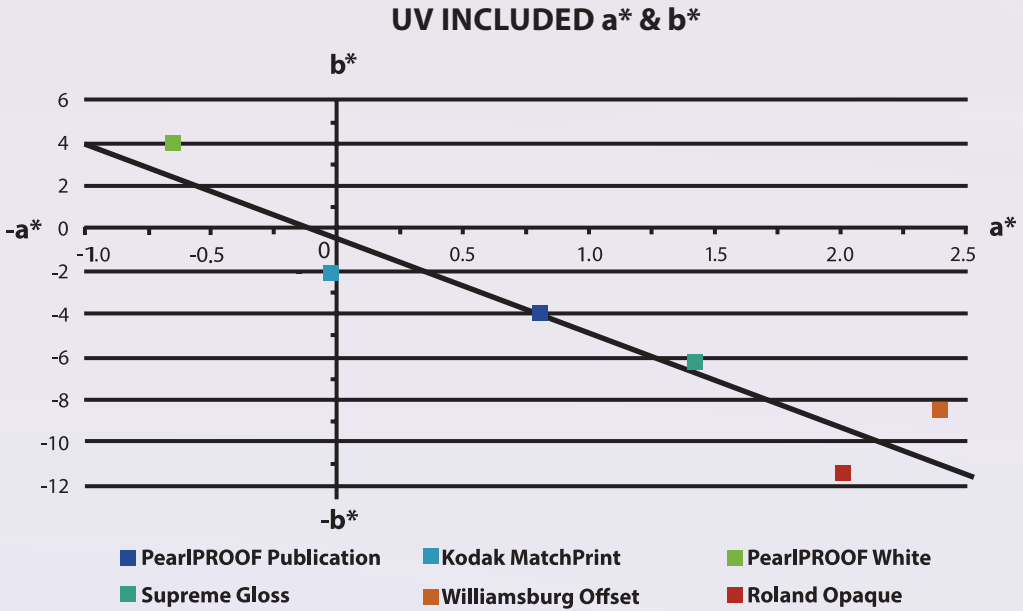
ANALYSIS

The results of the spectral reflectance measurements for each substrate provides a visualization of the difference in reflection percentage for a measurement with UV light included (M1), and with UV light excluded (M2). The difference between the M1 and the M2 values can be seen in approximately the 400-500 nm wavelength area of spectrum, where in theory the larger the space between the two data sets, the more OBAs are present (Kraushaar, 2013). This is most apparent in the Roland Opaque sample as seen in Figure 1.6, where at its highest point is showing a reflectance of 113% at 440 nm in M1 mode, but only shows a reflectance of 91% at

same wavelength in M2 mode. Similar results can be seen in the Williamsburg Offset sample as seen in Figure 1.5, where the M1 measurement showed a reflectance of 106% at its highest point at 430 nm and a reflectance of 85% at the same point under M2. Both of these results visually demonstrate a relatively high difference, which translates to a higher amount of OBAs present in the substrate.

On the other side of the spectrum, the spectral reflectance graph of the ORIS PearlPROOF Publication as shown in Figure 1.1 shows a very minimal difference, if any at all, between the M1 and M2 measurement modes. This is occurring for this specific substrate because it is actually advertised as OBA free. The Kodak MatchPrint Proofing paper in Figure 1.2 shows a minute difference between the two measurement modes,

which is only visible in the 420-450 nm areas of the spectrum. These very minimal differences lead to the assumption that there are minimal to no OBAs present at all in the substrate.

The two remaining substrates are the PearlPROOF White in Figure 1.3 and the Supreme Gloss in Figure 1.4; both of which have a moderate difference between the M1 and M2 spectral reflectance measurements. PearlPROOF White had its highest reflection point of 98.5% at 430 nm for the M1 measurement and 88% at the M2 measurement at the same wavelength. Supreme Gloss had its highest reflectance point at 430 nm where the M1 measurement reached 100% and the M2 measurement reached 87%. The results from these two samples can visibly demonstrate that there are a moderate amount of OBAs

present in the substrates, as the reflectance difference between the M1 and M2 measurements is much greater than that of the Kodak MatchPrint or PearlPROOF samples, but much lower than that of the Roland Opaque or Williamsburg Offset samples.

Looking at Figure 2.1, the calculated Δb* results draw a similar conclusion as was found in the analyzation of the graphs from Figure 1; the PearlPROOF Publication and Kodak MatchPrint samples both had very low Δb* values, both less than 2. The Williamsburg Offset and Roland Opaque samples have very high Δb* values at 7.864 and 9.643 respectively. Meanwhile, the PearlPROOF White and Supreme Gloss samples sit in the middle of these two values at 3.993 and 4.716 respectively. The Δb*

results come from a simple calculation using the b* values of L*a*b* measurements to put a number to the visible differences on the spectral reflectance graphs. This enables a quantification of the spectral reflection changes that are undergone when measuring with (M1) and without (M2) UV light, and in turn provides a method to communicate the amount of OBAs present in a substrate. This is possible because OBAs "absorb light in the ultraviolet region of the spectrum and emit light in the blue region of the visible spectrum" as shown in the b* values (where -b* describes a colour's blueness) of an L*a*b* measurement (Wales, 2008).

Figure 2.1 also shows a similar calculation that was performed to ideally achieve a more accurate numerical represen-tation of the samples' OBA

contents; this result is ΔB. The substrates demonstrate a similar order of ΔB results as Δb* results (where PearlPROOF Publication had the lowest and Roland Opaque had the highest). However, the values themselves increased. Not only that, but the increase occurred relatively linearly, where as Δb* increased, ΔB increased at a rate of $y = 1.4963x + 0.0246$ (as seen visually in Figure 2.3).

As the resulting Δb* and ΔB values differ, their classified OBA contents as established by Dr. Kraushaar (2013) in Figure 2.2 vary. In both cases, PearlPROOF Publication and Kodak MatchPrint have only a "faint" amount of OBAs present. The PearlPROOF White substrate, however, is classified as having a "faint" amount of OBAs if the Δb* result is used at 3.993, but comes up under the "low" category if using the ΔB result. Similarly, Williamsburg Offset sits in the "low" category with its Δb* result at 7.864, but comes up as "moderate" with a ΔB result of 11.702, and Roland Opaque is considered to contain a "moderate" amount of OBAs with Δb* at 9.643 and a "high" amount with ΔB at 14.832. These differences could have occurred due to the way the equations themselves are set up. ΔB uses the M1 and M2 measurements; however, the equation assumes that the illuminant is D65, which is neither an industry standard nor the illuminant present in the X-Rite eXact Spectrophotometer (Millward, 2014). Δb*, on the other hand, simply uses the L*a*b* values measured under both measurement conditions and cannot be affected by standard illuminant changes, as it does not account for it at all.

Even with the varying OBA amount classifications, the

resulting data can still provide an accurate depiction of the amount of OBAs present in a substrate, relative to the other samples. In all three examinations (spectral reflection graphs, Δb* calculations and ΔB calculations), the PearlPROOF Publication sample showed the least amount of OBAs compared to all other samples, followed closely by the Kodak MatchPrint paper. This is due to the fact that both of the substrates are classified as proofing papers, which are specifically produced with little OBAs (or none at all in the case of PearlPROOF Publication, as specified by the paper manufacturer) in order to achieve accurate colours under a variety of light sources (Pady, 2008). The PearlPROOF White followed as the paper with the third lowest amount of

OBAs, which is surprising considering it is a proofing paper and can be considered to have a faint amount of OBAs present, depending on which method of calculation is used. Supreme Gloss came in as the substrate with the third highest OBA content, followed by Williamsburg Offset as the second highest, and Roland Opaque as the highest OBA content.

The results in Figures 3.1 and 3.2 demonstrate a comparison of the a* and b* values from the L*a*b* measurements under the M1 mode. The graph visually shows each substrates position in a 2-D colour space, describing their respective blueness or yellowness, and redness or greenness. The trend line shows that when measuring the L*a*b* values of a substrate while including UV light in the light source, there is a slight

correlation between the substrates a* and b* values; where as the paper becomes more blue, it also ventures further into the red side of the spectrum. Additionally, if the substrates location on the trend line is compared with the order of OBA content shown in Figure 2.1, it could be concluded that as the OBA content of the substrate increases, the blueness of the substrate increases as well, generating a more negative b* value. This provides a visual representation and further proof of the concept that OBA content is most apparent in the blue area of the spectrum, where it absorbed the UV light is emitted (Myers, 2013).

Overall, the results confirmed some areas of the hypothesis but rejected others. The hypothesis was correct when it was assumed that the OBA free paper (PearlPROOF Publication) would demonstrate very minimal OBA content. However, it was incorrect to assume that all proofing substrates such as PearlPROOF Publication, PearlPROOF White and Kodak MatchPrint, would show little to no OBA content. In fact, the PearlPROOF White showed a significant amount more when compared to its OBA free counterpart. Similarly, the hypothesis was also incorrect to assume that the coated substrates would show the highest amount of OBAs; it was actually the uncoated samples that demonstrated these values. Finally, the hypothesis was also incorrect in assuming that the Δb* and ΔB results would be relatively similar. The calculated results were actually quite different, and in some cases translated to different OBA content classifica-tions. A possible weakness of the test is the conditions in which

the measurements were taken, as the substrates were all measured using an additional paper scrap to avoid measurement errors due to the reflective table surface. However, the paper scrap itself could have altered the reflectance data if one of the sample sheets was not particularly opaque. This could make a sample seem more reflective or have a higher OBA content if the X-Rite eXact Spectrophotometer picked up any UV fluorescence from the scrap paper. An ideal situation to alleviate this issue would be to measure all paper samples over a confirmed OBA free substrate, so that non-interference could be guaranteed.

CONCLUSIONS

It was seen that there are three separate methods to measure and quantify the OBA content of paper. However, the spectral reflectance method using M1 and M2 modes does not allow for a value to be specified as the exact content amount. Additionally, the Δb^* and ΔB methods do not calculate the content value in the same way, thus, providing varied results which do not always agree once classified into OBA amount categories (as seen in, for example, the Williamsburg Offset result). OBAs contain "fluorescence [which] causes the printed sample to look bluer and brighter […] but then the colours do not always match the proof" (Sharma, 2014). Depending on what light source a paper or printed product is being viewed under by its observer, its colours can appear

differently. The same concept applies to measurement devices such as spectrophotometers; older devices than the X-Rite eXact generally use the M0 mode, with an unspecified light source. Therefore, it is important that the industry collectively establishes a correct method of determining the OBA content of a substrate, so that these values can be used uniformly and be understood by all. As well, it is necessary that the knowledge of the M1 and M2 measurement modes, as well as the devices that can perform these measurements becomes more widespread. This would allow for the industry as a whole to move forward and attain even more colour accurate proofs and prints, satisfying not only printers, but customers as well.

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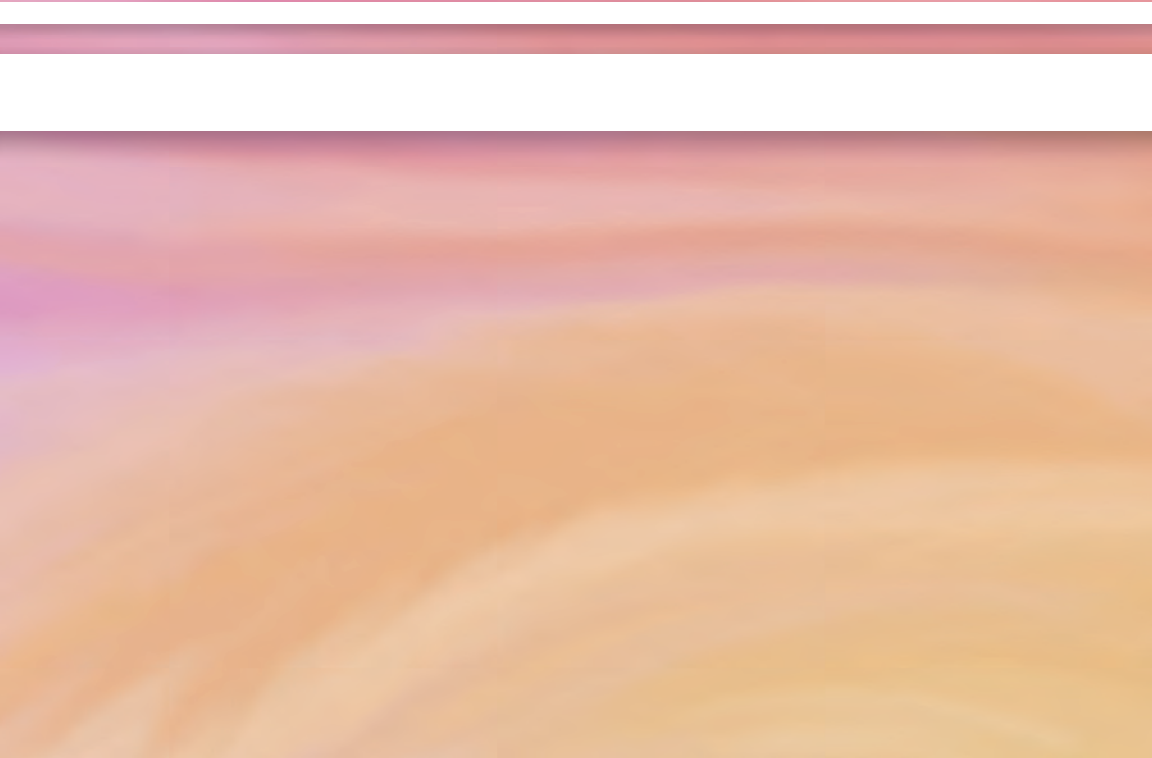
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COMPARING EXISTING SPECIFICATIONS – GRACOL, SWOP & SNAP – TO THE NEW 2013 CRPC DATA SETS

By: Hannah Gonzalez & Adriana Sarmiento

ABSTRACT

A barrier currently exists in the printing industry when using specifications and standards for colour reproduction. To this day, different regions around the world have certain specifications they use but there is no international standard that is used worldwide, which lead to the creation of ISO 15339, containing a new set of seven printing standards known as Characterized Reference Print Conditions (CRPC). New CRPC data sets span the range of expected colours used for colour reproduction of print material, regardless of the printing process. Their dependence lies in the substrate that will be used for the final product and they must take into consideration the characteristics of certain paper types, which is currently not as prominent. A special feature of these data sets is that they will now be measured using a new geometric measuring mode known as M1, which captures the UV content of paper containing Optical Brightening Agents (OBAs). This helps to eliminate discrepancies in colour when proofing, since most current proofing papers do not contain OBAs and printing papers often do. In this study, the new standards and their respective features will be evaluated and their similarities and differences will be compared to the existing specifications used in North America, which are Specifications for Non-Heatset Advertising Printing (SNAP), Specifications for Web Offset Publications (SWOP) and General Requirements for Applications in Commercial Offset Lithography (GRACoL). Chromix ColorThink Pro was used to input the data, to find the gamut size volumes and to create vector graphs that will allow to see the change in L*a*b* values of aim points within a gamut volume when going from an existing specification to a new 2013 CRPC standard.

INTRODUCTION

For a long time, the printing industry has struggled with the ability to reproduce colour accurately and efficiently across different print systems. This problem has generated much discussion within the industry, which is why specifications were created to try and correct this. Specifications help control the colour reproduction process by having a set of best practices that people in the graphic arts industry can follow in order to produce quality products. These specifications, along with ISO 12647 (a process control for the production of half-tone colour separations, proof and production prints), outline parameters for printing when using different processes to get consistent results.

The expectation is that if every company adheres to these specifications, they will reproduce colour in the exact same way and will end up with the same results, regardless of the printing process they use. However, the idea of better control through the use of

specifications was adapted in different ways by multiple regions of the world. This meant that specifications made and used in North America were not the same as the ones used in Europe or Asia. The United States of America uses specifications created by the Committee for Graphic Arts Technologies Standards (CGATS), which include SNAP, SWOP, GRACoL and Flexographic Image Reproduction Specifications and Tolerances (FIRST). The guidelines in these specifications differ from those found in the specifications used in Japan and in Germany (Fogra Graphic Technology Research Association, FOGRA). This is one of many reasons why discrepancies in colour can still occur, specifically when files originating in one region are transferred to be printed elsewhere, where different ICC profiles will be used for output.

In 2013, CGATS began implementing a new set of standards that were proposed and drafted under ISO 15339

TABLE 1

Characterized Reference Printing Conditions and the material they are specific to.

CHARACTERIZED REFERENCE PRINTING CONDITIONS	MATERIAL
CRPC 1	Coldset
CRPC 2	Heatset
CRPC 3	Premium Uncoated
CRPC 4	Super Calendared
CRPC 5	Publication Coated
CRPC 6	Premium Coated
CRPC 7	Extra Large

(printing from digital data across multiple technologies). These new standards, named Characterized Reference Printing Conditions, were put forward in the hopes of using them as a new common colour language on an international level. Currently, research shows that these new standards are slowly being implemented in North America but have not been formally adopted by ISO. There are now seven different standards to be used and each focus on colour reproduction using a specific paper type as represented in Table 1.

The purpose behind CRPCs is to provide better, more uniform control over colour repro-duction in print by using reference colour characteriza-tion data over process control data and by focusing on paper types that will be used.

With a limited amount of characterization data sets (seven in total), the colour reproduction process for a specific paper type will be much more narrow and easier to manage to be able to produce consistent colour from anywhere in the world. Another advantage of these new standards is that because each is used for a particular type of paper, all characteristics associated with that paper will

now be considered. Currently, the colour reproduction problems occurs during proofing because proofing papers do not contain OBAs that certain printing papers do. In an effort to make colour management much easier, these new standards will also be measured using a newly developed geometric measuring mode known as M1, which is able to include UV content when measuring colour. Using the new standard and the M1 measuring mode to measure colour, colour can be accurately managed since these two take into consideration of the effect of OBAs on paper and what will be of the resulting printed colours.

To make more sense of these new data sets, this study was conducted to compare the new standards with existing specifications in North America. The most relevant comparison would be between gamut volumes of the new standards and their paper types matched to the printing process used with the existing specifications. When the data sets were first downloaded from the International Color Consortium website for each CRPC, the description above where the data began stated which substrate it was intended for (ICC Profile Registry). CRPC 1 to 6 are specific to paper types and CRPC 7, also known as Extra Large, is used for extra large gamut printing processes such as digital printing and printing using spot colours. The hypothesis was developed using this information to match each standard with an existing specification and a prediction of the comparable gamuts is shown in Table 2. To formally begin the research, the data sets were gathered for all the standards and specifications from the ICC website and were inputted into Chromix ColorThink Pro to analyze and compare gamut volumes and to create vector graphs in order to determine colour changes that can occur when switching from specification to standard.

TABLE 2

Hypothesized results of matches between standards and specifications.

CRPC 2013	EXISTING SPECIFICATIONS
CRPC 1 – Coldset Newsprint	SNAP 2007
CRPC 2 – Heatset Newsprint	SNAP 2007
CRPC 3 – Premium Uncoated	GRACoL
CRPC 4 – Super Calendared	GRACoL
CRPC 5 – Publication Coated	SWOP 2006
CRPC 6 – Premium Coated	GRACoL 2006
CRPC 7 – Extra Large	N/A

SOFTWARE

- Chromix ColorThink Pro 3
- Microsoft Excel 2013

CHROMIC COLORTHINK PRO 3

The data sets were inputted for the specification profiles (for example, SWOP 2006) into Microsoft Excel and sorted from ascending order, according to the CMYK targets (CMYK of 0, 0, 0, 0 would be at the top of the worksheet and 100, 100, 100, 100 is at the bottom). After opening ColorThink Pro and clicking on the 3-D tab, the "Plot List" fly out menu appears. The text file is placed into the plot list and selected to be plotted as vectors. The destination is set as the CRPC profile that is being compared to (CRPC 5). This created a vector diagram with the specification being the starting point and the CRPC being the destination. Afterwards, the magnitudes of change for the L*a*b* values were analyzed.

RESULTS

GAMUT VOLUMES

After inputting the CRPC ICC profiles into ColorThink Pro, the gamut volume sizes were each determined. The CRPCs were numbered in relation to their gamut volume from CRPC 1 being the smallest to CRPC 7 being the largest.

The ICC profiles were inputted for SNAP 2007, SWOP 2006 and GRACoL 2006 into ColorThink to establish which are comparable to the new Characterized Reference Printing Conditions. The results are shown in Table 3.

VECTOR DIAGRAMS IN COLORTHINK

After determining which existing specification is comparable to the new CRPCs, a vector diagram was created to show the magnitude of change between the L*a*b* values of aim points. There were small noticeable changes between SNAP 2007 and CRPC 1 and CRPC 2 since these displayed short vectors. When comparing CRPC 5 to SWOP 2006, there were larger vectors in the green and blue areas; hence, a larger change in L*a*b* values and smaller vectors in the red area, meaning a smaller change in L*a*b* values. When analyzing the vectors for the comparison between SWOP 2006 and CRPC 5, and GRACoL 2006 and CRPC 6, there was an interesting similarity, which was that the vectors in the white areas were pointing towards the blue axis for both.

FIGURE 1

Figure 1 provides a visual representation of the gamut volume values from Table 3 and a comparison between existing specifications and new 2013 CRPC data sets using gamut volumes.
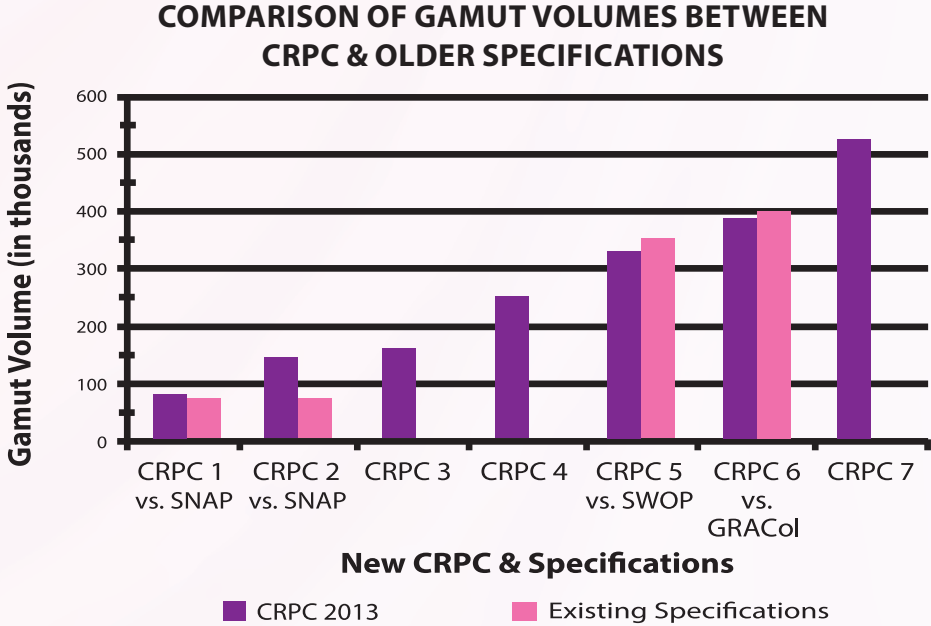
COMPARISON OF GAMUT VOLUMES BETWEEN CRPC & OLDER SPECIFICATIONS

TABLE 3

CRPC and comparable existing printing standard, along with the gamut volume sizes.

CRPC 2013	EXISTING SPECIFICATIONS
CRPC 1 – Heatset Newsprint Gamut Volume: 84,280	SNAP 2007 79,511
CRPC 2 – Coldset Newsprint Gamut Volume: 151,311	SNAP 2007 79,511
CRPC 3 – Premium Uncoated Gamut Volume: 165,764	N/A
CRPC 4 – Super Calendared Gamut Volume: 253,711	N/A
CRPC 5 – Publication Coated Gamut Volume: 331,416	SWOP 2006 354,962
CRPC 6 – Premium Coated Gamut Volume: 389,023	GRACoL 2006 398,316
CRPC 7 – Extra Large Gamut Volume: 525,551	N/A

ANALYSIS

With the volumes computed in ColorThink Pro, the specifications that are currently used were identified to the new standards that are to be approved by ISO. As shown in Table 2, some of the CRPCs can be compared while others cannot. These stand-alone standards were created because the corresponding paper types, such as premium uncoated, are often used within the industry and giving them their own profile can accurately show the colours they can reproduce.

CRPC 1, CRPC 2 & SNAP 2007

After inputting both CRPC 1 and SNAP 2007, the ICC profiles had a similar size in gamut volume. Initially, these two were to be compared because CRPC 1 is used for Coldset Newsprint, which is a process for newsprint where the inks are not dried and do not set properly; thus, causing black smudges when handling the newspaper.

CRPC 2, on the other hand, had a slightly larger gamut volume compared to SNAP 2007. This is because it uses "improved newsprint paper." These were compared because CRPC 2 is used for Heatset Newsprint, which is a process used for newsprint where the inks are dried with heaters. Presentation slides from Rochester Institute of Technology (RIT) confirm that CRPC 1 and CRPC 2 are used for newsprint; therefore, can be comparable to SNAP 2007 (McDowell, 2013). After analyzing the gamut volumes, vector graphs were created to examine the L*a*b* changes between the two data sets. There were short vectors throughout when comparing CRPC 2 and SNAP 2007, which means there was very little change, as shown in Figure 4. The prediction was correct since CRPC 1 and CRPC 2 were comparable to SNAP 2007.

FIGURE 2

Gamut volume comparison between CRPC 1 (true colour) and SNAP 2007 (red solid).
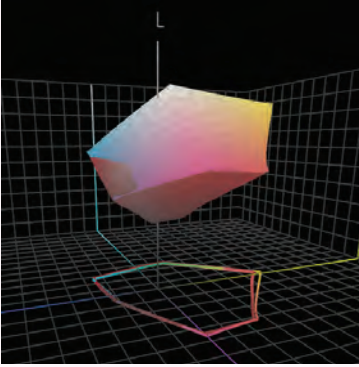

FIGURE 3

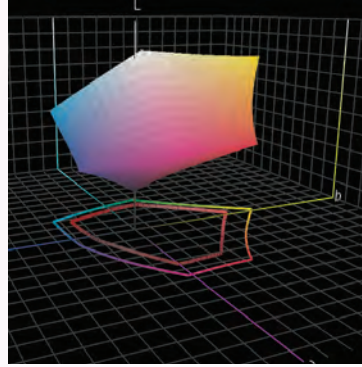Gamut volume comparison between CRPC 2 (true colour) and SNAP 2007 (red solid).
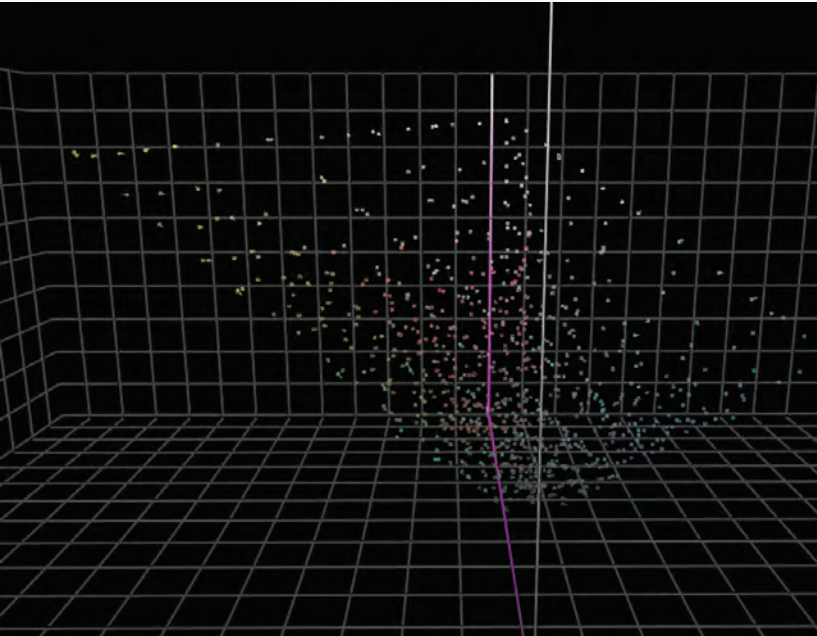

FIGURE 4

Vectors displayed when comparing CRPC 2 and SNAP 2007.

CRPC 5 & SWOP 2006

A visual representation is possible with the use of the 3-D graph in ColorThink. As shown in Figure 5, SWOP 2006 has a slightly larger gamut volume than CRPC 5. The vector graph showed a large change in the L*a*b* values of the blue and green areas, and a much smaller change in the red and magenta areas of the gamut volume. This can been seen in Figure 6, which shows an overview of the entire gamut and its changes. Figure 7 specifically shows the shorter vectors, representing a small change in the red and magenta colours. The prediction matching CRPC 5 and SWOP 2006 together was correct according to published sources.

FIGURE 5

Gamut volume comparison between CRPC 5 (true colour) and SWOP 2006 (red solid).
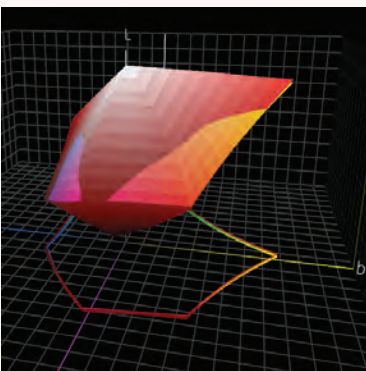
FIGURE 6

Vectors displayed when comparing CRPC 5 and SWOP 2006.

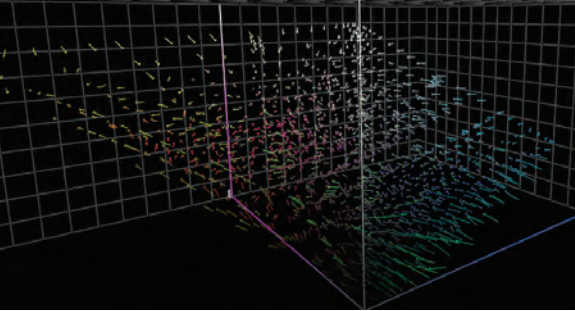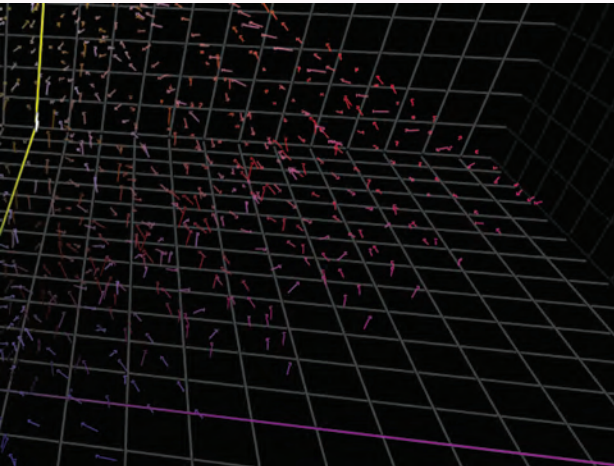## FIGURE 7

Short vectors seen in the red and magenta areas are representing a smaller magnitude of change in L*a*b* values when going from SWOP 2006 to CRPC 5.

CRPC 6 & GRACOL 2006

When comparing CRPC 6 and GRACoL 2006, there were several observations. Firstly, their sizes in gamut volumes are similar. There are certain areas that CRPC 6 can reproduce that GRACoL 2006 cannot and vice versa. CRPC 6 can reproduce colours with a higher L* value and brighter colours, while GRACoL 2006 can reproduce more colours with a lower L* value, as shown in Figure 8. Secondly, the L*a*b* values varied between data sets when using CMYK aim points. The green areas, for example, had a larger magnitude of change between the colours of the same CMYK data sets and are shown in Figure 9. There were smaller changes within the red and magenta areas, as shown in Figure 10.

FIGURE 8

Comparison between gamut volumes where the true color gamut is CRPC 6 and the red solid gamut is GRACoL 2006.
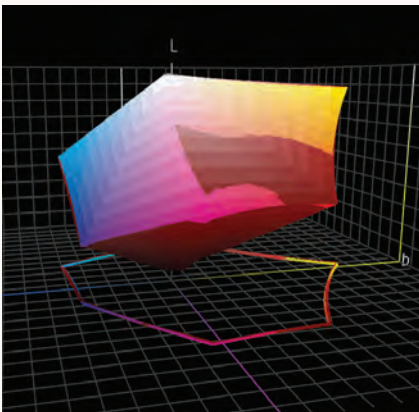
FIGURE 9

GRACoL 2006 to CRPC 6 vector graph that shows the green areas, which are where there is a larger magnitude of change.
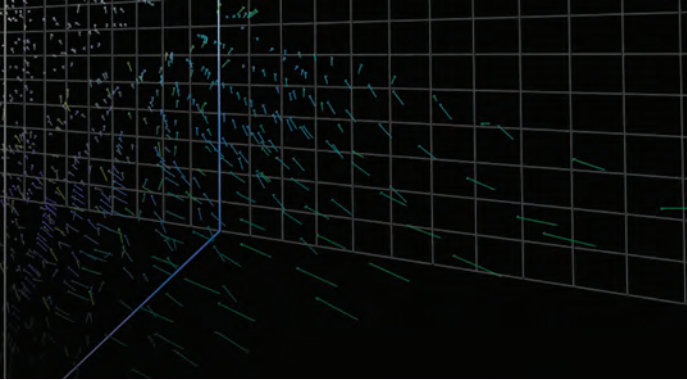

FIGURE 10

This shows the areas where there are smaller differences in L*a*b* values between CRPC 6 and GRACoL 2006.
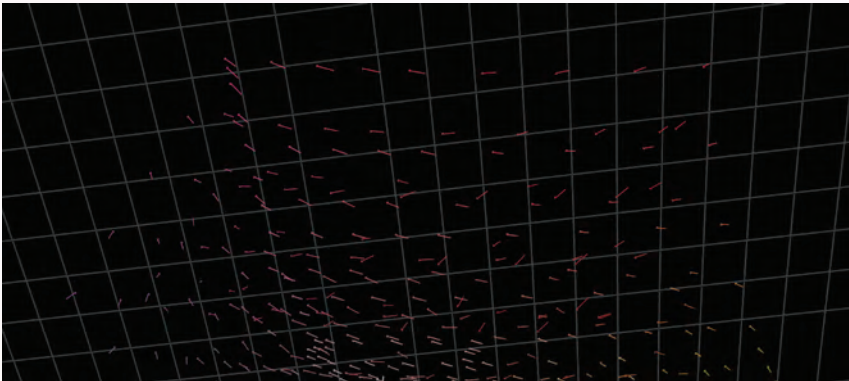
FIGURE 11

The vectors show that the GRACoL 2006 aim points in the white are moved towards the blue axis for CRPC 6.
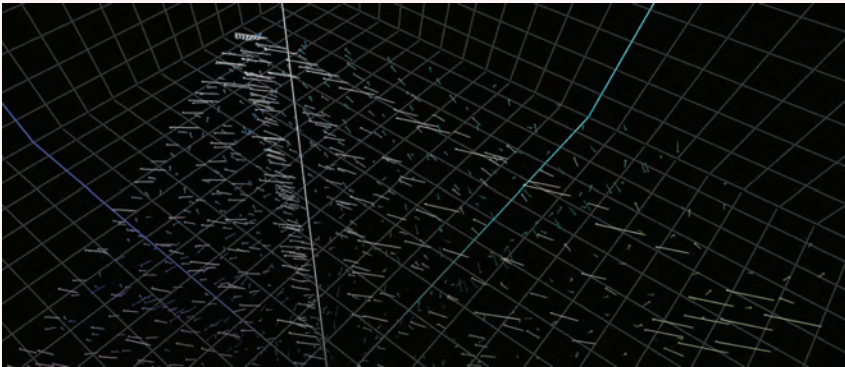
Finally, the vectors in the white points were pointing towards the blue axis in the CIELAB 3-D graph, which is shown in Figure 11. This is where the OBAs play a role in colour as OBAs affect the L*a*b* values, specifically the b* values; thus, making the colour more blue. For example, a CMYK value of 0, 0, 0, 0, also known as the white point of the paper, has a b* value of -2 for a Type 1 Gloss Coated paper under GRACoL 2006. GRACoL 2006 does not take OBAs into consideration when determining the L*a*b* values, resulting in a false representation of the colour that is expected. CRPC 6 uses the M1 measuring mode, which takes the effect that OBAs have on paper. The actual b* value of the white point of paper is -4, which is shown using CRPC 6.

According to these results, the hypothesis is confirmed to be true in some areas according to CRPC 6 and GRACoL 2006. It was predicted that GRACoL 2006 could be compared to CRPC 3 (Premium Uncoated), CRPC 4 (Super Calendared) and CRPC 6 (Premium Coated), since these paper types are often used in offset lithography. However, results only confirmed that CRPC 6 and GRACoL 2006 were comparable since they had a similar gamut volume. CRPC 3 and CRPC 4 do not have an existing specification they are comparable to, but since they are often used in the industry, it is important to know their colour reproduction capabilities; thus, the need for their own data sets.

CONCLUSIONS

Overall, the main purpose of ISO 15339 is to develop a universal colour language. This reduces the amount of colour management errors when outputting a job in a different region and ensures colour remains as consistent as possible. This is important for branding purposes where companies want to ensure consistent colour throughout all publications worldwide. This builds a strong brand image and helps the brand colour to become iconic in the mind of the consumer. By using the CRPC data sets we will be using profiles that have an accurate colour reproduction specific to the paper type and will allow colour management to be completed efficiently.

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4

METHODS TO CALCULATE THE NUMBER OF REPRODUCIBLE SPOT COLOURS FOR DIFFERENT PRINTING PROCESSES

By: Diondra Filicetti

ABSTRACT

This experiment tests the number of PANTONE+ Solid Coated spot colours that are within the printable gamut of different printing processes represented by the following ICC Profiles: Coated GRACoL 2006, Coated SWOP 2006 Grade 3, Coated SWOP 2006 Grade 5 and a custom profile for the Heidelberg Printmaster 74-4-P at the School of Graphic Communications Management. This experiment does this by exploring methods to analyze the number of reproducible spot colours within particular ΔE allowances, using various measurement programs (Chromix ColorThink, Esko Color Engine Pilot and Argyll CMS V.1.6.3). By looking at the percentage of spot colours that can be reproduced by different printing processes, one can evaluate how well suited a printing process is to producing various PANTONE+ Solid Coated colours. This provides an easy to understand metric that represents the gamut volume of a device, e.g. "Device X can reproduce 60% of the PANTONE library." Understanding the methodology behind the process of calculating the number of reproducible spot colours is important in order that this process can be applied to other situations in which the user is trying to determine the reproducible number or percentage of any set of colours in a given profile. Beyond this, this methodology can be used to compare different devices using their ICC profiles to determine which process is best suited to reproducing a specific set of colours for a specific client or job. The comparison of different methods (using different programs) of calculating the number of reproducible spot colours showed that each method returned similar results. Therefore, the choice of measurement method does not significantly impact the results. What then differentiates the programs is the ease of use, cost, and ancillary features.

INTRODUCTION

NATURE OF THE TOPIC

This experiment makes use of Chromix ColorThink Pro 3.0.3, Esko Color Engine Pilot Version 14.0.1, and Argyll CMS V.1.6.3 to measure the number of PANTONE+ Solid Coated spot colours that fall within the printable gamut of different printing processes, i.e., Coated GRACoL 2006, Coated SWOP 2006 Grade 3, Coated SWOP 2006 Grade 5, and a custom profile for the Heidelberg Printmaster 74-4-P at the Heidelberg Centre, School of Graphic Communications Management in Toronto, Ontario. Figure 1 shows a 3-D comparison of the gamut volume of Coated GRACoL 2006 in relation to the PANTONE+ Solid Coated library. At a glance, one can see that some PANTONE+ Solid Coated spot colours fall within the printable gamut, while others do not.

FIGURE 1

3-D comparison of Coated GRACoL 2006 and PANTONE+ Solid Coated Library.
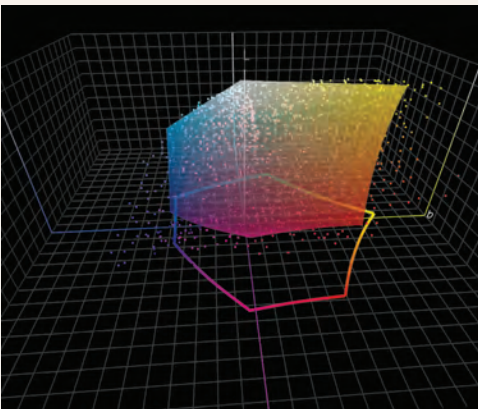
PURPOSE

The purpose of this experiment is to understand the procedures and methodology involved in measuring the reproducible PANTONE spot colours of a printing process, within various ΔE_{00} tolerances. This experiment is relevant in understanding the process to measure how well a printing process or device can reproduce any known set of colours, whether it is a PANTONE library or not. Many printing companies market their gamut size as a competitive advantage; however, it is important to understand how to apply the gamut size data by determining the amount of colours that fall within this gamut. This experiment is also important in selecting a printing process when deciding how to run a job that is meant to be able to reproduce particular colours. By understanding the basics on how to analyze gamut size in relation to particular colour values, one can apply this knowledge to test whether their printing process is suitable for reproducing their desired colours.

STATEMENT OF PROBLEM

What is the process using various methods to calculate the number of reproducible PANTONE+ Solid Coated spot colours in an ICC profile representing different printing processes? How do the different printing processes differ in reproducing PANTONE spot colours and does it relate to the gamut volume? Do different programs measure this differently?

HYPOTHESIS

Prior to conducting the experiment, the predicted results were that GRACoL 2006 would achieve the best results, producing the greatest number of PANTONE+ Solid Coated spot colours. The custom profile would produce the second greatest number of spot colours because the Printmaster 74 (PM 74) is maintained and calibrated to the GRACoL specifications.

SWOP 3 would produce the second lowest number of spot colours, and SWOP 5 would produce the lowest number of spot colours. These predictions were made after observing the gamut volume of each profile in ColorThink. Predictions also included that all three-measurement methods would incur similar if not the same results for each profile.

TABLE 1

PROCESS	COLORTHINK GAMUT VOLUME
GRACoL 2006	403,137
PM 74	364,856
SWOP 3	355,586
SWOP 5	307,257

EXISTING KNOWLEDGE

In regards to printing PANTONE spot colours without the use of specially formulated inks, different printing processes will be able to accurately produce a number of PANTONE spot colours (Sharma, 2009). Depending on the printable gamut of each printing process, certain spot colours will fall inside the printable gamut, whereas other spot colours will not. For the spot colours that are within the printable gamut, these colours can be produced with accuracy. For the spot colours that fall outside of the printable gamut, there will be some colour difference that can be indicated by ΔE.

DESCRIPTION OF THE EXPERIMENT

This experiment makes use of three different colour management technologies. In order to conduct this experiment, a colour value list in L*a*b* format is required in order to test these colours against the different ICC Profiles (Coated GRACoL 2006, Coated SWOP 2006 Grade 3, Coated SWOP 2006 Grade 5, and a custom profile for the Heidelberg Printmaster 74-4-P at GCM).

In this experiment, the colour value list consisted of the PANTONE+ Solid Coated colour library. This colour library was used in ColorThink Pro in ICC format (generated from PANTONE Color Manager), and in Argyll CMS in a text file format. Esko Color Engine Pilot is loaded with certain colour books and for this experiment, the PANTONE+ Solid Coated book was already loaded. This existing colour book was used. Each software followed a different procedure to generate the number of reproducible spot colours in the PANTONE+ Solid Coated library for each printing process. Esko Color Engine Pilot calculates these values quite automatically with particular settings. ColorThink and Argyll CMS follow the general format of mapping the PANTONE+ Solid Coated L*a*b* values to CMYK equivalents using the B2A table in the ICC profile and the Absolute Colorimetric rendering intent. Afterwards, the CMYK values are converted back to L*a*b* values where the differences can then be communicated by the ΔE. The ΔE values can then be analyzed in Microsoft Excel by sorting the numbers in ascending order.

EXPERIMENTAL SETUP

MATERIAL (PROFILES TO ANALYZE)

- CoatedGRACoL2006.icc
- WebCoatedSWOP2006_Grade3.icc
- WebCoatedSWOP2006_Grade5.icc
- Filicetti_PM74_D50_150330.icc (measured from GCM's Heidelberg Printmaster 74-4 P)

EQUIPMENT

- Chromix ColorThink Pro 3.0.3
- Esko Color Engine Pilot Version 14.0.1 Build 45
- Argyll CMS V.1.6.3 for Apple OS (Experiment done using OS X Yosemite Version 10.10.1)
- Microsoft Excel (for Mac 2011 Version 14.2.0 was used)
- Microsoft Word (for Mac 2011 Version 14.2.0 was used)
- Terminal (Version 2.5)

EQUIPMENT TO CREATE CUSTOM PROFILE

- X-Rite i1iSis SN: 005165
- X-Rite i1 Profiler Version 1.5.6 software

PROCEDURE

*Please note that the PANTONE+ Solid Coated ICC Profile generated from PANTONE Color Manager contained more PANTONE colours than the PANTONE+ Solid Coated ink book installed in Esko Color Engine Pilot. For this reason, consider the reproducible percentage of the library as opposed to the number of reproducible spot colours.

*Also note that the custom profile (Filicetti_PM74_D50_150330.icc) was created in i1 Profiler after

measuring an IT8.7/4 target printed from GCM's Heidelberg Printmaster 74-4 P. This profile was chosen in order to compare the press capabilities to standard profiles. Any custom profile could have been chosen. The purpose of this report is not focused on how to create an ICC profile after characterizing a device; however, it focuses on the methods to measure the number of spot colours within the device gamut. These methods can then be applied to various ICC profiles to test the different device gamut in relation to spot colours, or any colour of interest.

In order to acknowledge the use of a custom profile in the experiment, the following procedure was followed using the X-Rite i1iSis and X-Rite i1 Profiler software.

1. Obtain a printed IT8.7/4 characterization target from the specified device or press (In this case, the IT8.7/4 was printed on GCM's Heidelberg Printmaster 74-4 P by Peter Roehrig, Technician at GCM).
2. Connect the i1iSis to a Mac computer equipped with i1 Profiler software.
3. In i1 Profiler, in Advanced Mode, select Profiling.
4. Select the test chart in use (IT8.7/4 R CMYK 1P ISIS XL BC).
5. Select the Dual Scan measurement mode.
6. Feed the test chart into the i1iSis after clicking Measure.
7. Once measured, set the lighting to CIE Illuminant D50.
8. In the Profile Settings tab, leave most default except:
   • Total Ink Coverage: 320
   • Table Size: Large
   • Granularity: 16 bit
   • ICC Profile Version: 2 (Version 4 will not work well with Argyll)
9. Save the ICC profile as: Filicetti_PM74_D50_150330.icc

USING CHROMIX COLORTHINK PRO 3.0.3

1. Obtain a PANTONE+ Solid Coated ICC Profile from PANTONE Color Manager with 2618 PANTONE colours.
2. Import the PANTONE+ Solid Coated ICC Profile into ColorThink by dragging and dropping the ICC Profile over the ColorThink application icon. Click on Export color list.
3. Import the CoatedGRACoL2006 ICC profile into ColorThink, so that the two colour lists are adjacent to each other. Import the CoatedGRACoL2006 ICC profile into ColorThink a second time, so that the CMYK values are now listed as L*a*b* values.
4. Specify the Absolute Colorimetric rendering intent.
5. Click on the ΔE icon and make sure it is set to ΔE_{00} to compare the PANTONE Coated spot colours to the GRACoL gamut.
6. Save the ΔE_{00} list as a text file.
7. Analyze the text file in Microsoft Excel (Sort the data in ascending order to determine the number of spot colours under specific ΔE_{00} tolerances).
8. Repeat steps 2-7 for each ICC Profile.

USING COLOR ENGINE PILOT 14.0

1. Import the necessary ICC Profiles to analyze by going to ICC Profiles > Press > Register
2. Go to Tools > Gamut Check
   • Enter the following information:
   • Check Inkbook: PANTONE+ Solid Coated
   • For: Profile
   • Profile: CoatedGRACoL2006.icc
   • Gamut Mapping: Closest Color (Classic)
   • ΔE Formula: Delta E 2000
3. Specify the ΔE tolerance and record the percentage of spot colours that are reproducible.
4. Repeat steps 2-4 for each ICC Profile.

USING ARGYLL CMS V. 1.6.3

1. Download the free software from argyllcms.com (This experiment was conducted using the executables for "Intel OS X 10.6 64 bit or later" for Apple OS X).
2. Follow the installation instructions provided by argyllcms.com
3. Export a text file of the PANTONE+ Solid Coated spot colours in L*a*b* form to use as the input values.
4. Drag the xicclu bin folder into the Terminal.
5. Use this sequence: xicclu –fb –ia profile.icc <input.txt> output. txt (Be sure to specify the location of your generated output.txt file).
   • -fb specifies the backward function, which uses the B2A (L*a*b* to CMYK) LUT (look-up table)
   • -ia specifies the Absolute Colorimetric rendering intent
6. Open the output.txt file in Microsoft Excel using columns where the data is separated by spaces. Delete all the excess data, leaving only the CMYK values (both clipped and unclipped).
7. Use this CMYK list as your new input file when following this sequence: xicclu –ff –ia profile.icc <inputCMYK.txt> output. txt. This will result in the L*a*b* values of the clipped and unclipped CMYK values.
   • -ff specifies the forward function, which uses the A2B (CMYK to L*a*b*) LUT
8. Compare this L*a*b* list to the original PANTONE+ Solid Coated text file in ColorThink Pro in order to generate a ΔE_{00} list. Before importing the text files into ColorThink, convert the text files into ANSI CGATS format by adding BEGIN_DATA as the header and END_DATA at the end of the data list, in addition to specifying the format between BEGIN_DATA_ FORMAT and END_DATA_FORMAT.
9. Follow steps 4-8 for each of the ICC Profiles.

RESULTS

TABLE 2

Using Chromix ColorThink Pro 3.0.3 (Total of 2,618 PANTONE spot colours observed).

Process	ΔE_{00}									
	Less than 1		2		3		4		5	
	#	%	#	%	#	%	#	%	#	%
GRACoL	1,360	52	1,640	63	1,872	72	2,076	79	2,264	86
SWOP 3	1,104	42	1,440	55	1,670	64	1,910	73	2,128	81
SWOP 5	958	37	1,226	47	1,422	54	1,660	63	1,880	72
PM74	1,366	52	1,708	65	1,932	74	2,086	80	2,228	85

TABLE 3

Using Color Engine Pilot 14.0 (Total of 1,799 PANTONE spot colours observed).

Process	ΔE_{00}									
	Less than 1		2		3		4		5	
	#	%	#	%	#	%	#	%	#	%
GRACoL	932	51	1,069	59	1,202	66	1,350	75	75	82
SWOP 3	804	44	953	52	1,083	60	1,221	67	67	76
SWOP 5	693	38	815	45	925	51	1,071	59	59	67
PM74	935	51	1,091	60	1,236	68	1,347	74	74	81

TABLE 4

Using Argyll CMS V.1.6.3 (Total of 2618 PANTONE spot colours observed).

Process	ΔE_{00}									
	Less than 1		2		3		4		5	
	#	%	#	%	#	%	#	%	#	%
GRACoL	1,388	53	1,654	63	1,858	71	2,086	80	2,260	86
SWOP 3	1,160	44	1,460	56	1,674	64	1,906	73	2,118	81
SWOP 5	994	40	1,248	48	1,452	55	1,678	64	1,888	72
PM74	1,442	55	1,712	65	1,932	74	2,092	80	2,226	85

FIGURE 2

Percentages of reproducible spot colours measured in Chromix ColorThink.

% OF REPRODUCIBLE SPOT COLOURS MEASURED IN CHROMIX COLORTHINK

Legend: SWOP 5, SWOP 3, GRACoL, PM 74

x-axis: ΔE_{00} (< 1, < 2, < 3, < 4, < 5)
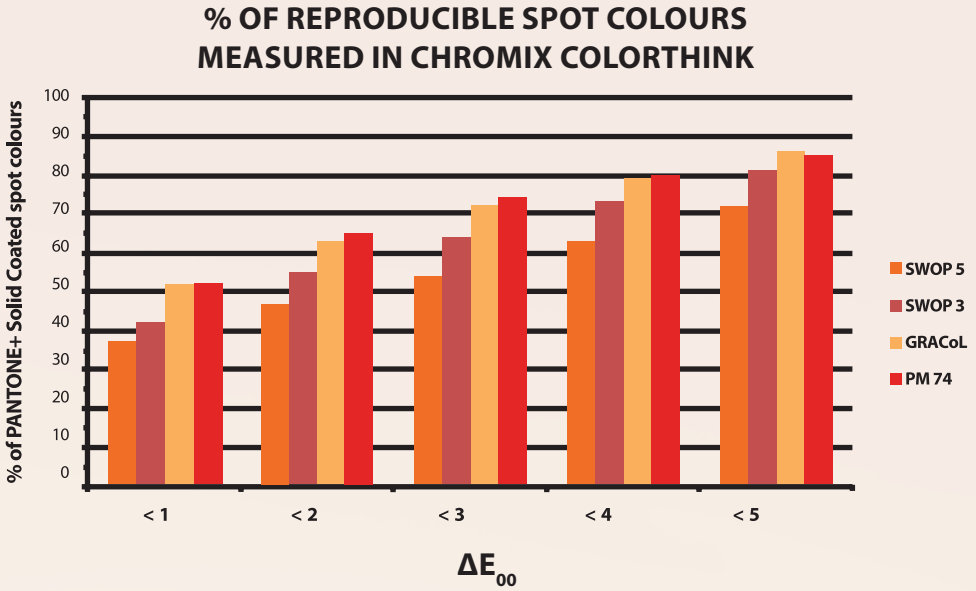
y-axis: % of PANTONE+ Solid Coated spot colours

FIGURE 3

Percentages of reproducible spot colours measured in Esko Color Engine Pilot.

% OF REPRODUCIBLE SPOT COLOURS MEASURED IN ESKO COLOR ENGINE PILOT

Legend: SWOP 5, SWOP 3, GRACoL, PM 74

x-axis: ΔE_{00} (< 1, < 2, < 3, < 4, < 5)
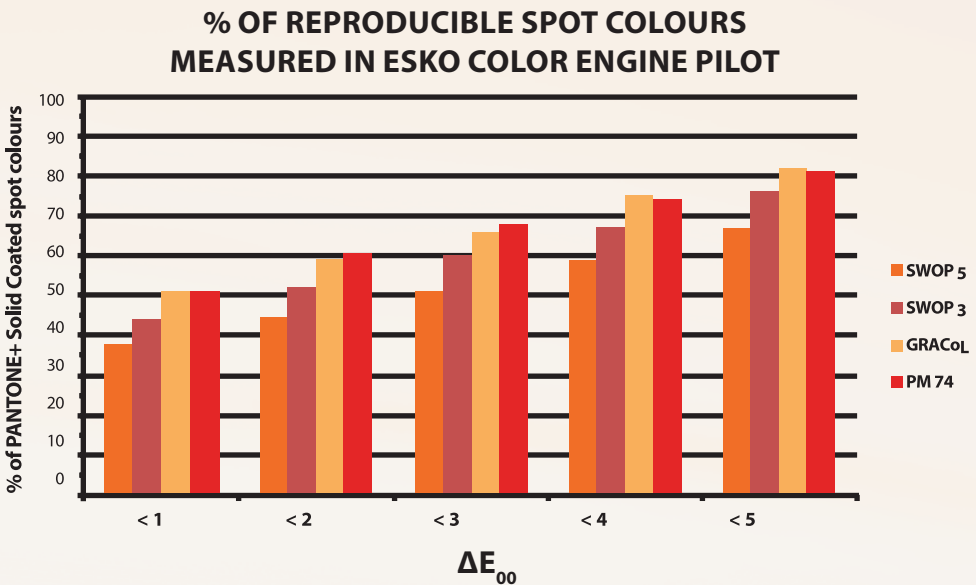
y-axis: % of PANTONE+ Solid Coated spot colours

FIGURE 4

Percentages of reproducible spot colours measured in Argyll CMS.

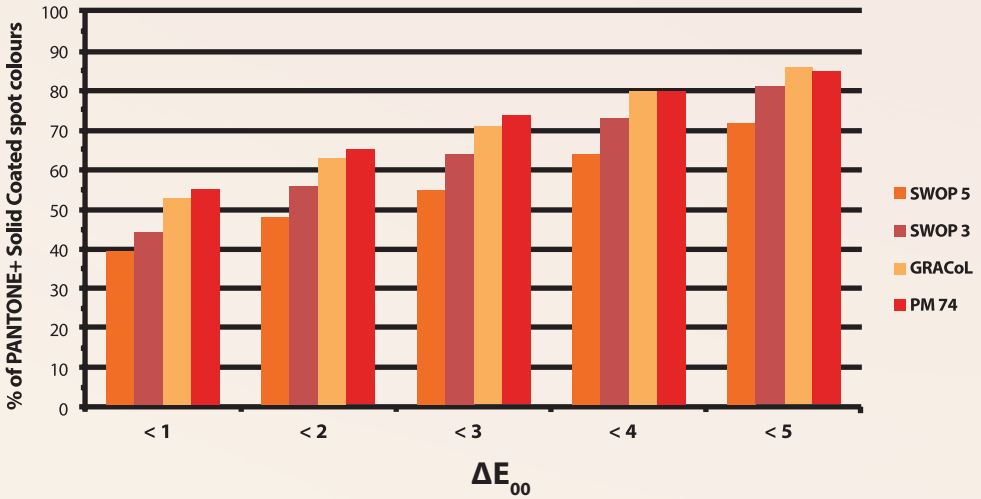### % OF REPRODUCIBLE SPOT COLOURS MEASURED IN ARGYLL CMS

Y-axis: % of PANTONE+ Solid Coated spot colours

X-axis: ΔE_{00}: < 1, < 2, < 3, < 4, < 5

Legend: SWOP 5, SWOP 3, GRACoL, PM 74

FIGURE 5

Percentages of reproducible spot colours measured in by different colour management programs at 1.0 ΔE_{00}.

% OF REPRODUCIBLE SPOT COLOURS MEASURED BY DIFFERENT COLOUR MANAGEMENT PROGRAMS AT 1.0 ΔE_{00}

Y-axis (left): % of PANTONE+ Solid Coated spot colours

Y-axis (right): ColorThink Gamut Volume

X-axis: ICC Profile — SWOP 5, SWOP 3, GRACoL, PM 74

Legend: ColorThink, Color Engine Pilot, Argyll CMS, ColorThink Gamut Volume
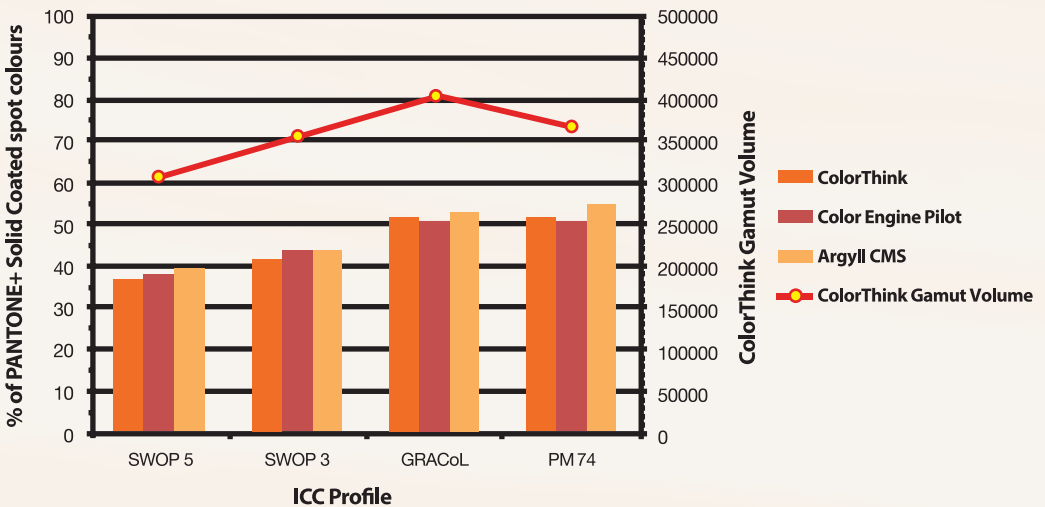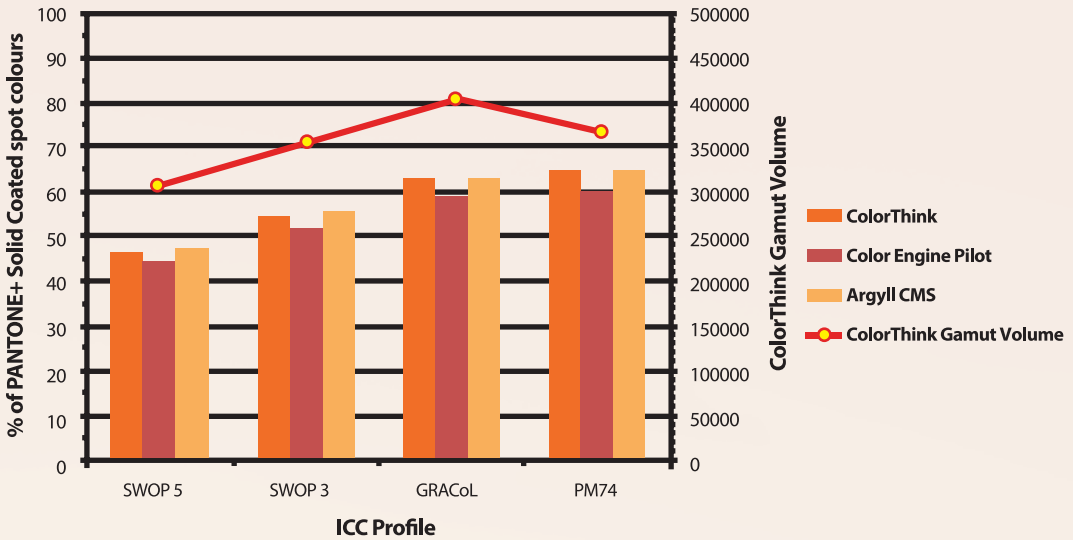
FIGURE 6

Percentages of reproducible spot colours measured in by different colour management programs at 2.0 ΔE_{00}.

% OF REPRODUCIBLE SPOT COLOURS, MEASURED BY DIFFERENT COLOUR MANAGEMENT PROGRAMS AT 2.0 ΔE_{00}

In regards to quality standards, a ΔE of less than 1.0 is a very small, almost undetectable difference and a ΔE of up to 2.0 is usually acceptable at a top quality level (Breede, 1999).

ANALYSIS

Between the different methods (Chromix ColorThink, Esko Color Engine Pilot and Argyll CMS V.1.6.3), the process to calculate the number of reproducible spot colours differed. All three methods shared similar results, which show that both a packaged shelf solution such as ColorThink or Color Engine Pilot and a command line solution will be able to generate the desired results. There are certain advantages and disadvantages to each method, which are further discussed in the report.

CHROMIX COLORTHINK (AS SHOWN IN FIGURE 2)

In order to measure the number of reproducible spot colours in ColorThink, a ΔE_{00} list between the PANTONE+ Solid Coated L*a*b* values and the ICC Profile L*a*b* equivalent is analyzed. In order to do this, the process requires that the PANTONE+ Solid Coated spot colours be mapped to CMYK values using the B2A look-up table of the Absolute Colorimetric rendering intent in the ICC Profile in use. Chromix ColorThink does this automatically when the PANTONE colour list is dragged into the workflow, followed by the ICC profile that is being tested. It is important to set the rendering intent to Absolute Colorimetric to utilize the look-up table that will give the most accurate colour conversion when the PANTONE L*a*b* values are being mapped

to the CMYK equivalent in the profile (Dharavath & Uttam, 2014). This rendering intent matches the original colours when possible and maintains the white point of the source profile; therefore, will not affecting the colours further by mapping them to a different white point (Sharma, 2004).
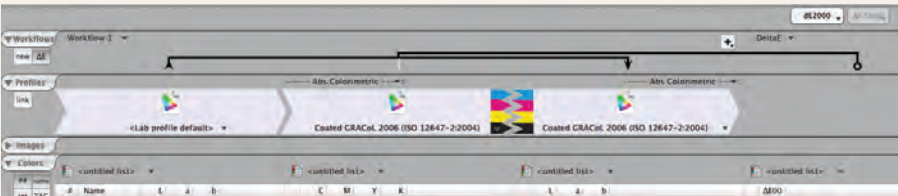
In the conversion from PANTONE L*a*b* to the CMYK equivalent in the profile, there will be some changes in the colours as they are moved into the gamut of the ICC Profile. Those colours that were already within the gamut will be matched. Once this is complete, the CMYK values must then be converted back to L*a*b* in order to compare the colour to the original PANTONE+ Solid Coated colours and generate ΔE_{00}. To do this, the ICC profile is dragged into the workflow

in ColorThink a second time, and ColorThink automatically computes and outputs the L*a*b* values. Again, ensure that the Absolute Colorimetric rendering intent is selected. At this point, ΔE_{00} can be calculated. By simply clicking on the ΔE button in the top left hand corner of the workflow, this can be accomplished. Ensure that ΔE_{00} is selected. Export the ΔE_{00} list, by right-clicking and using "Save List as." Once exported, the list can be opened in Microsoft Excel. For analysis purposes, delete the header information, so that only the

ΔE_{00} values are left. By sorting the data in ascending order (Data > Sort), identify the precise number of colours that are below 1.0, 2.0, 3.0, 4.0 and 5.0 ΔE_{00}. Figure 8 shows the path taken by the PANTONE+ Solid Coated spot colours as they are mapped into the gamut of Coated GRACoL2006.icc. In Figure 9, the GRACoL gamut volume is displayed in order to better visualize the PANTONE+ Solid Coated origin and destination in comparison to the GRACoL gamut volume. The points with the furthest trip or the longest line, indicate that PANTONE

FIGURE 7

This is a snapshot of what the workflow.

FIGURE 8

Path taken by PANTONE spot colours are mapped into GRACoL's gamut.
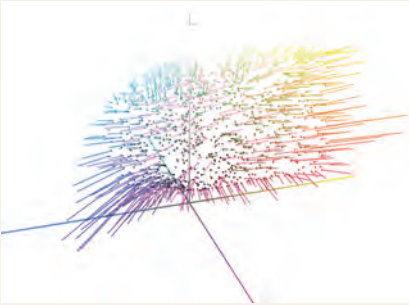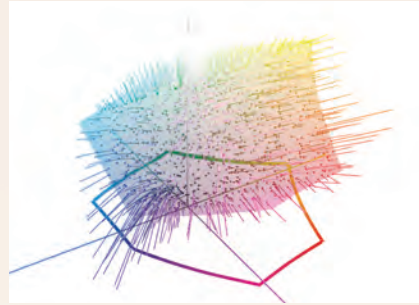

FIGURE 9

GRACoL gamut volume.

colours that are the furthest outside of the gamut and will generate the highest ΔE_{00} values. Chromix ColorThink Pro performs this process very automatically and does so in a very visual manner. In ColorThink, the gamut volume can be mapped in a 2-D space or as a 3-D volume.

This can be compared to individual PANTONE spot points, as shown in Figure 10 and Figure 11 using the Coated GRACoL 2006 ICC profile.

Very quickly, the user can visualize the spot colours that are within and outside of the gamut.

Figure 12 graphs all four ICC profiles at once in comparison to the PANTONE+ Solid Coated spot colours. This image allows the user to visualize the gamut to improve understanding of the relationship of gamut volumes between profiles, rather than comparing the number given to describe the gamut volume.
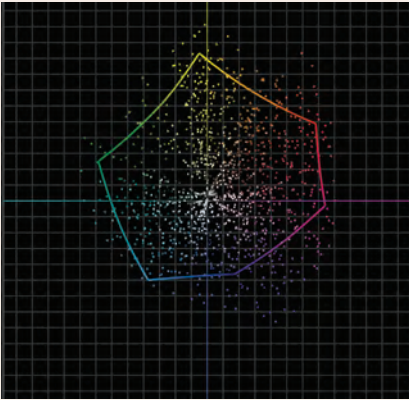
FIGURE 10

2-D view of gamut volume.

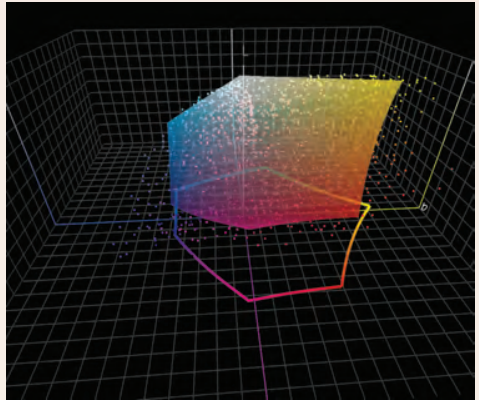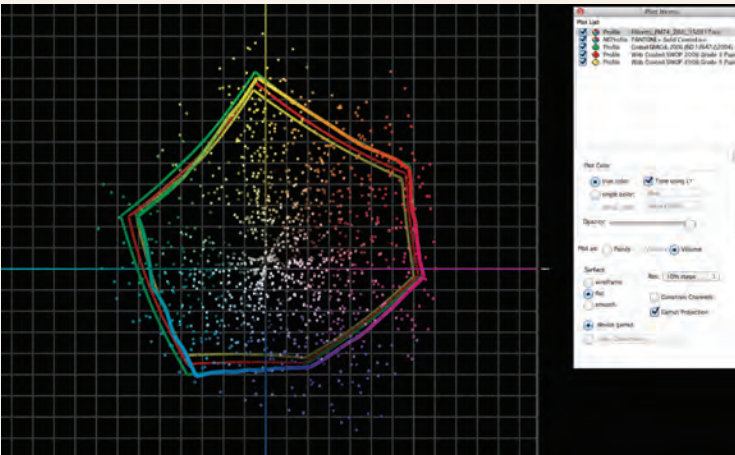## FIGURE 11

3-D view of gamut volume.

FIGURE 12

2-D view of gamut volume comparison of all four ICC profiles to the PANTONE+ Solid Coated spot colours.

ESKO COLOR ENGINE PILOT (AS SHOWN IN FIGURE 3)

Esko Color Engine Pilot offers ease of use with a user-friendly interface and convenience for the user. In order to determine the number of reproducible PANTONE+ Solid Coated spot colours in each ICC profile, the ICC profiles should first be registered in the ICC Profiles module as shown in Figure 13. Once this has been completed, Color Engine Pilot offers a tool called Gamut Check (as shown in Figure 14) which displays the percentage of colours in an ink book that are inside the gamut of different profiles. "Delta E 2000"

must be selected as the ΔE formula for this experiment. At the bottom of the window, the ΔE_{00} value for which is being tested can be selected to give the percentage of colours in the ink book that are under this selected ΔE_{00} value. The data can be further analyzed if desired by clicking "Save As" on the bottom right corner of the Gamut Check window. Here a text file can be exported to view the ΔE_{00} values in addition to the original input L*a*b*, the CMYK equivalent of the profile and the output L*a*b*.

FIGURE 13

Window for selecting ICC Profile.
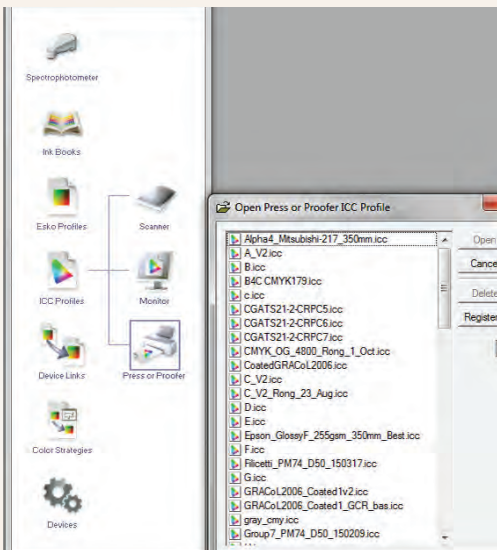
FIGURE 14

Gamut Check Window.
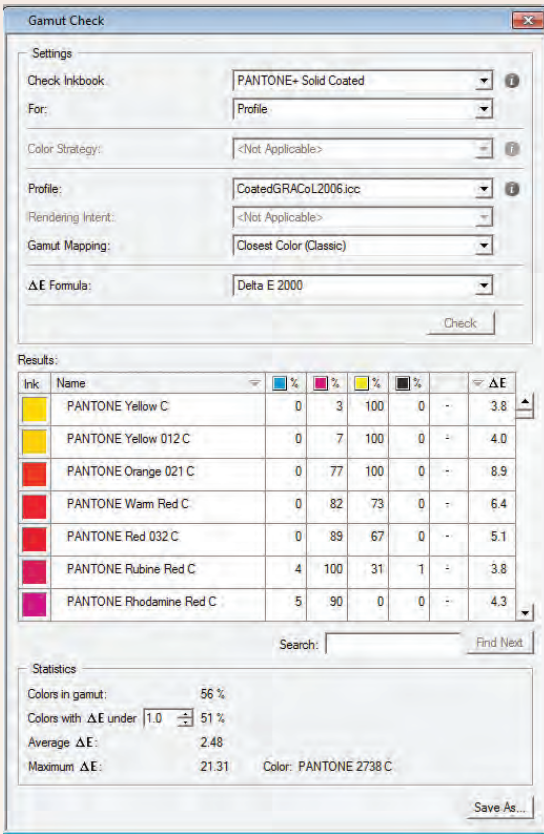
ARGYLL CMS (AS SHOWN IN FIGURE 4)

A weakness of measuring the number of reproducible spot colours in Argyll CMS is the interface. Using the Terminal and command lines on the Mac OS in order to perform the functions of the application can be very difficult to understand for first time users. Installation of

Argyll CMS is a manual process in which the downloaded folder is placed in the Applications folder of the Mac OS. The executives are then retrieved from the bin subfolder in the Argyll_VX.X.X folder where X.X.X is the version number (Gill, 2014-a). Also, performing

colour conversions in order to observe colour differences is a more tedious process in Argyll CMS than it is in ColorThink or Color Engine Pilot.

Using the xicclu executable from the bin folder offers the function of looking up individual colour values through any ICC profile in addition to reversing the look-up tables (Gill, 2014-b). In order to measure the number of reproducible PANTONE+ Solid Coated spot colours in different profiles, a properly formatted text file containing the L*a*b* values of the spot colours being tested, is required. The lines of the text file should end with CR/LF (Carriage Return / Line Feed). The CR/LF line ending is used by Windows and is compatible with the Argyll CMS software, allowing the data to be read

FIGURE 15

File Conversion Dialogue Box.
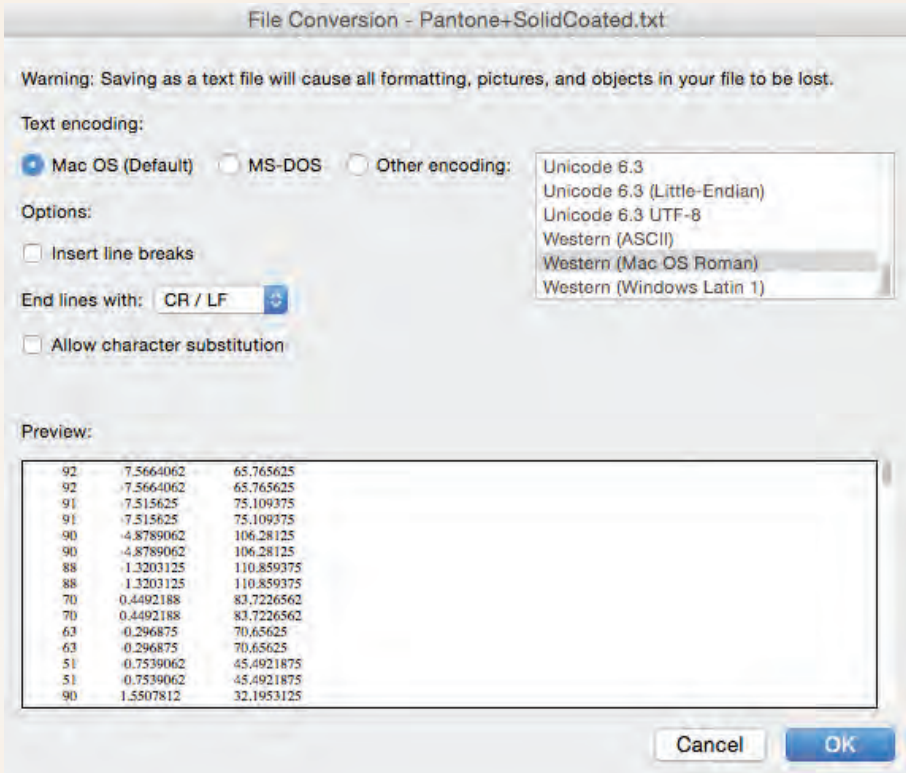
correctly (Miessler, 2015). The text files created on a Mac use the CR ending only; however, when used in Argyll CMS, the data output will not return all of the lines. In order to fix this, the text file can easily be saved in Microsoft Word in the file conversion dialogue box as shown in Figure 15.

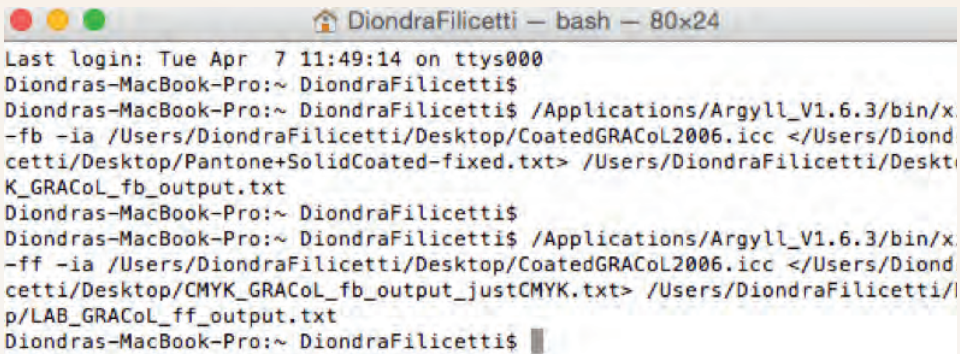This properly formatted text file can then be used in the Terminal with the xicclu executable. In order to export the PANTONE spot colour CMYK equivalent in each profile, –fb (backward function) and –ia (absolute intent) will be selected in the command line to use the Absolute Colorimetric B2A look-up table. There will be some colour difference between these CMYK values and the original PANTONE spot L*a*b* values because the spot colours had to be mapped to the gamut of the specified profile. The spot colours that were originally out of the gamut of the profile are specified by Argyll by displaying 'clip'. In order to quantify the colour difference or the amount by which the colours moved, the L*a*b* equivalent of the mapped CMYK values is required in order to calculate ΔE_{00}. This is performed by using –ff (forward function) and –ia (absolute intent) in the command line in order to utilize the A2B look-up table in the same ICC profile. This will deliver the L*a*b* values that can be further analyzed in Chromix Color-Think Pro to compute ΔE_{00}.

FIGURE 16

Screenshot of the functions that are in use in the Terminal. Information on file location must be included and specified.


```
Last login: Tue Apr  7 11:49:14 on ttys000
Diondras-MacBook-Pro:~ DiondraFilicetti$
Diondras-MacBook-Pro:~ DiondraFilicetti$ /Applications/Argyll_V1.6.3/bin/x.
-fb -ia /Users/DiondraFilicetti/Desktop/CoatedGRACoL2006.icc </Users/Diond
cetti/Desktop/Pantone+SolidCoated-fixed.txt> /Users/DiondraFilicetti/Deskt
K_GRACoL_fb_output.txt
Diondras-MacBook-Pro:~ DiondraFilicetti$
Diondras-MacBook-Pro:~ DiondraFilicetti$ /Applications/Argyll_V1.6.3/bin/x.
-ff -ia /Users/DiondraFilicetti/Desktop/CoatedGRACoL2006.icc </Users/Diond
cetti/Desktop/CMYK_GRACoL_fb_output_justCMYK.txt> /Users/DiondraFilicetti/l
p/LAB_GRACoL_ff_output.txt
Diondras-MacBook-Pro:~ DiondraFilicetti$ █
```

It is important to consider that ColorThink requires the text file to be formatted according to the CGATS standard. By default, Argyll CMS does not output CGATS text files.

The ANSI CGATS.17-2009 is the standard text file format for exchanging colour data where BEGIN_DATA is placed before the data begins and END_DATA is placed after the data ends (ColorWiki, 2012). In ad-dition, the data format must be specified between "BEGIN_DATA_FORMAT" and "END_DATA_FORMAT", an example is shown in Figure 17.

Once correctly formatted, the clipped L*a*b* data from Argyll can be directly compared to the original PANTONE+ Solid Coated L*a*b* data in ColorThink to compute ΔE_{00}, and export a ΔE_{00} list to further analyze in Microsoft Excel.

FIGURE 17

Example of CGAT text file.

FIGURE 18

A ΔE_{00} comparison between the original PANTONE+ Solid Coated L*a*b* values and the clipped L*a*b* values through the GRACoL profile from Argyll.
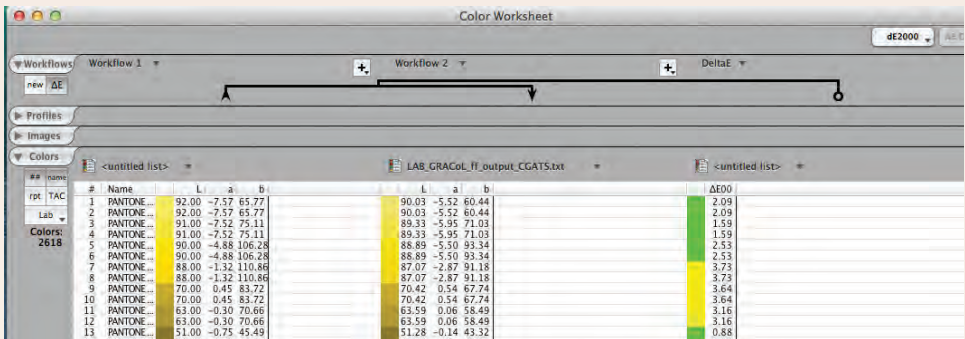
COMPARISON OF SOFTWARE

In a comparison of the three different colour management programs, it is evident that they generate similar results. As apparent in Figure 5 and Figure 6, the measurements from Argyll CMS and ColorThink were slightly higher than measurements in Color Engine Pilot software programs. This difference was proportional as there were similar increases in % of spot colours between different ΔE tolerances. Although there were different processes in each software program, the colour management concept is the same behind all the processes. This concept is a measurement of the colour difference (measured with ΔE_{00}) of the PANTONE+ Solid Coated spot colours when they are mapped into the gamut of various ICC Profiles. The mapping process occurs via the

Absolute Colorimetric rendering intent in order to achieve the closest colour match. The colour difference can then be prioritized and a percentage can be calculated after calculating the number of PANTONE+ Solid Coated spot colours are below ΔE_{00} tolerances of 1.0, 2.0, 3.0, 4.0, and 5.0.

The results confirm the original hypothesis in which similar results were achieved by all programs (ColorThink, Color Engine Pilot and Argyll). In addition, SWOP 5 is capable of producing the lowest number of spot colours and SWOP 3, the second lowest number of spot colours, agreeing with the gamut volume measured in ColorThink. Conversely, the custom press profile was able to reproduce a similar, if not greater, amount of spot colours than GRACoL, whereas the gamut volume of GRACoL was greater than that of the custom profile.

The percentage of spot colours that were reproducible by each printing process was related to the gamut volume of each ICC profile. Generally, the larger the gamut, the higher the percentage of reproducible spot colours. This held true for all ICC profiles except for the custom press profile measured in ColorThink and Color Engine Pilot. The custom profile measured in ColorThink and Color Engine Pilot was often equal to or slightly higher than the number of reproducible spot colours using GRACoL. This phenomenon can be explained by the existence of different methods to calculate gamut volume. Different calculation methods can result in slightly different results. Changes in gamut volume calculation do not change the calculation of the number of reproducible spot colours within a gamut because the number of reproducible spot colours is calculated via

look-up tables (Pope et al.). Therefore, the calculation of gamut volume by Chromix ColorThink may differ from another measurement software, which could deliver measurements that align with the results of this experiment, showing that GRACoL and the custom press profile have more similar gamut volumes.

The three different software programs make use of different Colour Management Modules (CMMs). The CMM is the engine that performs the conversion between colour spaces using device profiles (Sharma, 2004). CMMs are available from different vendors and the choice of CMM has a slight effect on the output colours due to variations in the intent of the CMM and the technology that went into the construction (Adams, 1999). The slight differences in results obtained from each software

can be attributed to the difference in CMM. Argyll CMS is a CMM on it's own, Color Engine Pilot uses a CMM, which is named Color Engine Pilot, and ColorThink uses Little CMS. Little CMS is a publicly available open source colour management engine that uses the International Color Consortium standard (Saguer, 2015).

Using ΔE is a good measure of print quality because it is an objective, numerical measure. In regards to quality standards, a ΔE of up to 2.0 constitutes a small difference and is usually acceptable at a top quality level (Breede, 1999). In regards to the a ΔE_{00} of 2.0 in this experiment, an average (between software programs) of 47% in SWOP 5, 54% in SWOP 3, 62% in GRACoL and 63% in the custom press profile, of PANTONE+ Solid Coated spot colours were reproducible.

PURPOSE OF RESULTS

Comparing the three procedures for calculating the percentage or number of reproducible PANTONE+ Solid Coated spot colours is important to determine whether there are differences in the method one chooses to calculate this metric. These results show that there is very little difference between the three programs. Depending on the intention and needs of the user, the selection of a software solution should not be determined by the accuracy of results because as proven, all three programs generated similar results. The choice of software will be based on the functionality and cost. Chromix ColorThink Pro and Esko Color Engine Pilot are more costly "off the shelf" solutions that offer the user an easy to use visual experience and user-friendly interface. Argyll CMS is offered for free download; however, it is more difficult to use and understand. This is relevant because users who might be students or small print shop owners might choose to use this solution over ColorThink or Color Engine Pilot, where they do not have the resources to purchase the larger "off the shelf" solutions. Larger companies or colour researchers might choose ColorThink or Color Engine Pilot as these solutions might be more affordable for them and more inline with their usage intention, especially if they require more graphical visualization of the workflow.

CONCLUSION

In this experiment, there are various methods to calculate the number of reproducible spot colours through an ICC Profile. The three tested methods generated similar results, which show that all three methods are viable solutions. The measured spot colour percentages were in agreement with the relative gamut volume (measured in ColorThink) of each profile, except for the custom press profile. SWOP 3 reproduced the lowest number of PANTONE+ Solid Coated spot colours and had the lowest gamut volume, followed by SWOP 5. GRACoL 2006 and the custom press profile were able to reproduce the most spot colours; however, the custom press profile had a lower gamut volume than GRACoL. The gamut volume is subject to change based on calculation method; therefore, a different method of calculating gamut volume in a different program could have generated different results.

The general conclusion that a greater gamut volume insinuates a larger reproducible percentage of spot colours aligns with the fact that a larger gamut (the range of colours that a device can produce) can reproduce more colours (Sharma, 2004).

The results confirmed the original hypothesis in that, in general, the greater the gamut

volume, the higher the number of reproducible spot colours in each process. The similarity between the results of custom press profile and GRACoL profile was surprising. The custom press profile had a lower gamut volume than the GRACoL profile; however, at certain ΔE_{00} tolerances, the different programs measured a slightly higher number of reproducible spot colours in the custom press profile than in GRACoL. Due to the fact that the PM 74 is maintained and calibrated to GRACoL specifications and gamut volume measurement changes between calculation methods, the hypothesis is acceptable in spite of the one misalignment of the custom press profile and its gamut volume. A weakness of this experiment is the

difference in PANTONE+ Solid Coated libraries used. In Esko Color Engine Pilot, the PANTONE+ Solid Coated ink book that was available contained only 1,799 colours, whereas the PANTONE+ Solid Coated library tested in Chromix ColorThink and Argyll CMS was an expanded library with 2,618 colours. In order to overcome this weakness, the focus was placed on the reproducible percentage of spot colours rather than the number. This allowed comparison between the three methods.

By assessing different methods to calculate the number of PANTONE+ Solid Coated spot colours that are reproducible by various printing process within specific ΔE tolerances, this

methodology can be applied to various situations. This methodology can be used to check whether one specific colour is within the printable gamut of a specific device, or can be used, as in this experiment, to determine the percentage or number of colours that are reproducible on various devices. This is important to understand the capabilities of the equipment in regards to colour reproduction.

In addition, the public can be more readily understand communicating colour capacity in terms of the reproducible percentage of a PANTONE book rather than communicating gamut volume numerically. Therefore, by measuring the percentage of reproducible percentage of a set of colours by a printing process through the use of an ICC profile, a printing company can offer their customers an easy to understand metric that speaks to the gamut volume of the device. Printing companies can also use this measurement as a selling point or a key metric if their customer is interested in being able to produce certain spot colours. The customer could then evaluate the printing company based on the percentage of a particular spot colour library, depending on their colour requirements.

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5

ACCURACY OF THE BEHR COLORSMART APPLICATION BY COMPARING THE DELTA E OF DIFFERENT SUBTRATES

By: Claire Poirier

ABSTRACT

This report measured the limits and capabilities of the ColorSmart mobile application. The purpose of the application is to correctly match a photograph of a colour to one of the Behr paint swatches. This experiment tested the accuracy of the application by measuring the L*a*b* values of each of the photographed images as well as the swatch matches. In total, there were nine separate substrates tested taken from various samples. Three colour samples were used from a photograph of kitchen wallpaper. Three separate patches will be tested from a photograph from the Behr Colour Collection swatch book. Finally, a swatch from the Behr Marquee Exceptional Performance lookbook was used, as a source for the last three separate patches will be tested. By comparing to their own swatch books, the goal was that the Behr ColorSmart application would match the photograph with the exact same colour from their collections. With respect to the wallpaper, the goal was to see that the application would match as close to the paper as possible. To determine the exact difference in colour, the L*a*b* values will be used to calculate the change of ΔE_{ab}. The results concluded that the Behr ColorSmart application made two perfect matches within the Marquee lookbook, it made the second closest matches with the wallpaper with one fair match and finally, it made close matches to the Colour Collection swatch book.

INTRODUCTION

STATEMENT OF PROBLEM

Colour accuracy is extremely important in the printing industry. Colour defines a brand as it changes the outlook of everything and its surroundings, and helps to realize the beauty of the world. When properly colour matching, ΔE_{ab} is the calculation used to make sure that the colour of two seperate L*a*b* values are close enough to be determined as acceptable matches.

The Behr ColorSmart application intends to match a colour from their paint swatches to any photograph that is inputted in the application. Once the perfect match is accurately found, the colour can then be saved and previewed in their virtual rooms. The accuracy of this application is what will was tested throughout this report.

In order to justly determine if this is an acceptable application, three seperate substrates were tested. Included in the testing was a sample of wallpaper, the Colour Collection Behr swatch book and finally, the Behr Marquee lookbook.

The reason in which both Behr swatch books was tested is because the Marquee lookbook is considered their exceptional performance line for their exterior paints. The paint itself, as well as the swatches in the lookbook, have a semi-gloss applied to them, which is known as their top of line paint colours (Behr, 2015). This differs from the Behr Colour Collection as these swatches have a matte coating applied, and are used as a more basic paint colour. This expanded the scope of this experiment to determine how the application could handle exterior factors, such as semi-gloss and matte appliqués applied, to see if it interrupts the colour matching, as well as to see if more expensively produced colours would attain a closer match.

HYPOTHESIS

In this experiment, it is expected that closer ΔE_{ab} matches will be found from using the Behr ColorSmart application and an image of the Behr upscale swatch books, instead of an image of wallpaper. It is hard to believe that it will make perfect matches for colour, as there are so many external factors that could influence the image alone that must be taken into consideration. A substrate with a glossy finish may reflect too much light and create glare on the photograph, creating a less accurate target to work from. However, from the three substrates tested, it is expected that the ΔE_{ab} would be closer to the Behr swatch books as they have been printed professionally and are untouched.

EXPERIMENTAL SETUP

EQUIPMENT

- iPhone 5s with an 8 megapixel camera
- Behr ColorSmatt mobile application - Version 2.0.17
- X-Rite 530 Spectrophotometer
- CRD-1 Colour Rendition Demonstrator - Daylight

MATERIAL

- Wallpaper Sample
- BEHR Premium Plus Behr Colour Collection Swatch Book
- BEHR Marquee Exceptional Performance Swatch Book

EQUATION

$$\Delta E_{ab} = \sqrt{\left(L^*_2 - L^*_1 \right)^2 + \left(a^*_2 - a^*_1 \right)^2 + \left(b^*_2 - b^*_1 \right)^2}$$

In order to properly create and follow through with this experiment, several steps had to be taken. To begin with, all the supplies had to be gathered, this included all of the testable substrates, including the wallpaper, the Behr Premium Plus Behr Colour Collection Swatch Book and the Behr Marquee Exceptional Performance Swatch Book, as well as the X-rite 530 Spectro-photometer, CRD-1 Colour Rendition Demonstrator, the iPhone 5s, and downloading the Behr ColorSmart application.

This report was done in two stages; the first stage was to take a proper photograph of each of the testable substrate on the iPhone 5s. The photograph was taken under proper D50 lighting, so that the colours appear as vivid and accurate as possible. After the photographs had been taken, they were then imported into the application, where the application determined the closest match from their array of paint colours.

The application then asked the user to choose the exact area in the photograph, in which the user would like to match. Once the spots were chosen, the matches were gathered. To obtain the matching swatches, Home Depot had a full section where they were readily available, allowing for further calculations to be made.

The second step of this process was to determine the exact L*a*b* values of each substrate by using the X-rite 530 Spec-trophotometer, thus, allowing the calculation of the ΔE_{ab} to be made. To calculate the ΔE_{ab}, Microsoft Excel made it possible by using the ΔE_{ab} equation under "Equation." To double check that this was correct, importing the L*a*b* values into Bruce Lindbloom's online colour difference calculator was extremely helpful (Lindbloom, 2015). Once the ΔE_{ab} was determined, then it was able to analyse the data and conclude if the hypothesis was valid or not.

MATCHES

Figure 1, Figure 2 and Figure 3 are the applications matches from taking photographs of each substrate under the D50 lighting. From these three set of matches, it was possible to get the corresponding colour swatches, so that the ΔE_{ab} could be determined, thus, explaining how accurate the application is.

FIGURE 1: WALLPAPER MATCHES

An image of the Behr ColorSmart matches from photographs of the wallpaper. The original data was gathered from the Behr Colour Smart Application, and the photos were taken on an iPhone 5s.
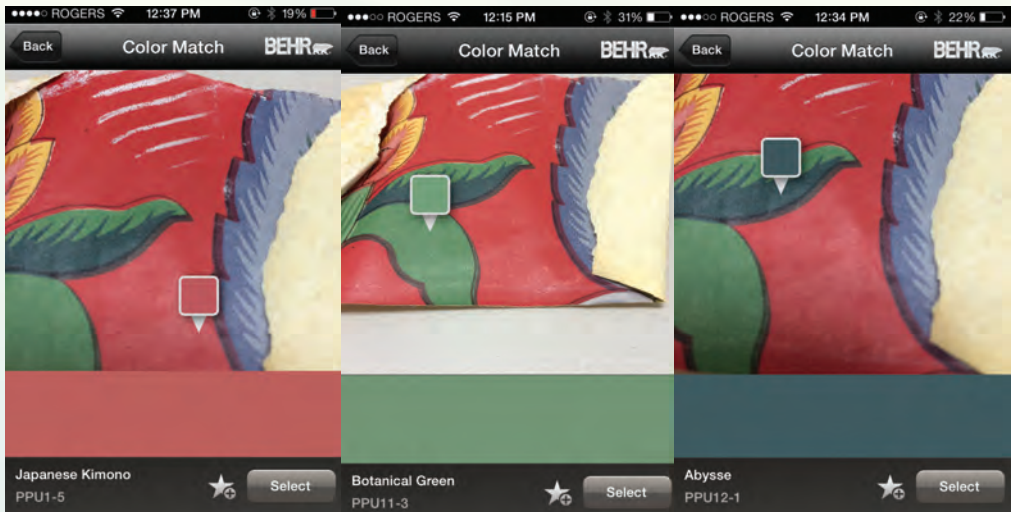
FIGURE 2: COLOUR COLLECTION MATCHES

An image of the Behr ColorSmart matches from photographs of the Colour Collection Matches. The original data was gathered from the Behr Colour Smart Application, and the photos were taken on an iPhone 5s.

FIGURE 3: MARQUEE EXCEPTIONAL PERFORMANCE MATCHES

An image of the Behr ColorSmart matches from photographs of the Marquee Exceptional Performance Matches. The original data was gathered from the Behr Colour Smart application, and the photos were taken on an iPhone 5s.
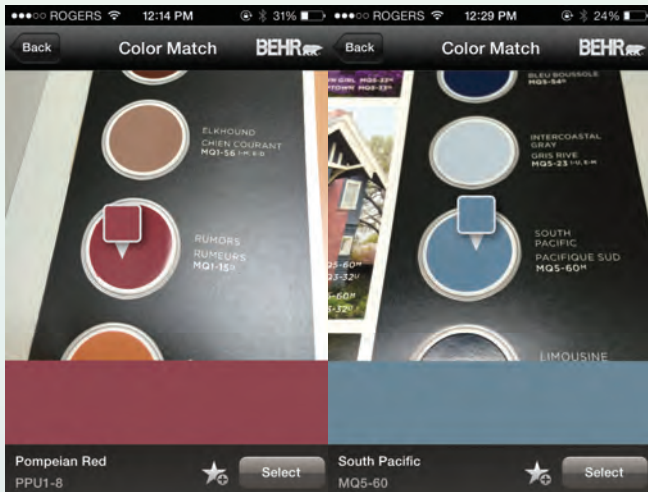
RESULTS

*Please note that the following; Table 1, Table 2 & Table 3 are based on the different L*a*b* values for each of the substrates followed by their matches. Alongside are the ΔE_{ab} values for the corresponding substrate and match values. The original data was gathered from the Behr Colour Smart Application, and the photos were taken on an iPhone 5s. The ΔE_{ab} was calculated with the X-Rite 530 Spectrophotometer.

TABLE 1: WALLPAPER MATCHES

SUBSTRATE	L*	a*	b*	ΔE_{ab}
Wallpaper Leaf	48.79	-17.5	12.35	10.97
Botanical Green (PPU11-3)	57.7	-21.47	17.37	
Wallpaper Dark Leaf	33.65	-9.13	-5.23	6.04
Abysse (PPU12-)	30.96	-10.39	-6.56	
Wallpaper Red	44.64	46.64	26.91	19.56
Japanese Kimono (PPU1-5)	57.86	33.53	20.89	

TABLE 2: BEHR COLOUR COLLECTION MATCHES

SUBSTRATE	L*	a*	b*	ΔE_{ab}
Peru (PPU1-18)	43.33	33.21	-11.02	8.58
Majestic Orchird (PPU1-17)	41.21	31.81	-2.82	
Morocco Red (PPU2-17)	38.61	38.18	24.29	11.89
Red Pepper (PPU2-2)	33.94	29.96	17.07	
French Silver (PPU18-5)	74.66	-0.8	-1.5	10.97
Green Balsam (PPU11-15)	68.15	-7.53	4.22	

TABLE 3: MARQUEE EXCEPTIONAL PERFORMANCE MATCHES

SUBSTRATE	L*	a*	b*	ΔE_{ab}
Rumors (MQ1-15)	26.26	35.93	13.76	14.95
Pompeian Red (PPU1-8)	40.85	32.75	14.49	
Coastal Jelly (MQ4-64)	32.35	-27.15	-28.86	0
Coastal Jelly (MQ4-64)	32.35	-27.15	-28.86	
South Pacific (MQ5-60)	49.37	-7.44	-14.67	0
South Pacific (MQ5-60)	49.37	-7.44	-14.67	

EXPLANATION OF L*a*b* & ΔE$_{ab}$

L*a*b* is a colour space in which colour is defined onto a three-dimensional axis. The L* stands for the lightness and darkness of the colour, in which a colour with an L* value of 100 would mean that the colour is bright, while a colour with an L* value of 0 would mean the colour is dark. A positive a* value means that the colour is a warmer red, while a negative a* would be a cooler green. A colour with a positive b* value means the colour is more yellow and a colour with a negative b* value would mean the colour is more blue. Thus, when using this to read the L*a*b* values from Figure 4, it is possible to comprehend the general colour without having to reflect back upon the corresponding swatches. Once the ΔE$_{ab}$ from these numbers is calculated, the calculated number can be used to analyze how close the colours are to matching. A ΔE$_{ab}$ greater then 8.0 is considered unacceptable, a ΔE$_{ab}$ less the 5.0 is considered a fair match, and a ΔE$_{ab}$ of 0.0 to 2.0 is considered unnoticeable by the human eye (Millward, 2015). The ideal ΔE$_{ab}$ would be a ΔE$_{ab}$ between 0.0-5.0, as the colours need to match as close as possible.

ΔE$_{ab}$ OF WALLPAPER MATCHES

The ΔE$_{ab}$ matches seen in Figure 6 represent the changes between the wallpaper colours and their correlated matches from the ColorSmart application. Due to the fact that this was the most complex substrate that was tested, it was surprising how accurate one of the matches was. The substrate was complex because it had several colours designed in the pattern within it, and the colours were uneven due to years and sun damage. The closest match was between the dark green of the leaf on the wallpaper and the colour match being Abysse. With a ΔE$_{ab}$ of

3.25, this match was considered to be good match, which is closer than any of the Behr Colour Collection matches. The human eye would not be able to predict a difference between the two colours. The second closest match was between the lighter green of the leaf and the Botanical Garden swatch. This match came out with a ΔE_{ab} of 10.97, which is unacceptable.

From a visual perspective, the substrates colour is a bit darker than the matched colour. Finally, the worst match was between the Wallpaper Red and the Japanese Kimono with a ΔE_{ab} of 19.56. The substrate is quite a vivid and dark red, in contrast to the Japanese Kimono wwthat was collected, as the match is a muted red, making this is an extreme colour difference.

FIGURE 4

A graphical representation of the ΔE_{ab} for each of the package matches. The original data was gathered from the Behr Colour Smart Application, and the photos were taken on an iPhone 5s.

ΔE_{ab} OF WALLPAPER MATCHES
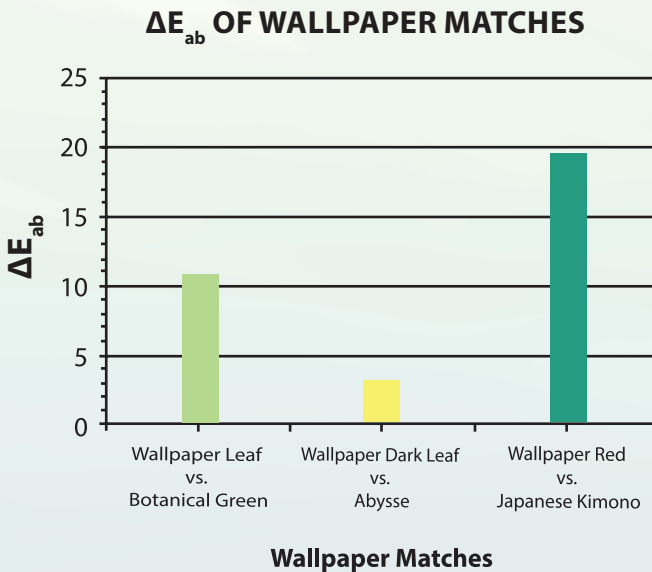
ΔE$_{ab}$ OF BEHR ULTRA COLOUR COLLECTION MATCHES

As seen in Figure 5, the data was plotted in a bar graph. This graph represents the ΔE$_{ab}$ of three separate Behr Colour Collection. The closest match between the three was found to be between the Peru and Majestic Orchard colours with a ΔE$_{ab}$ of 8.58. When going through the Colour Collection palette book, the colours are arranged in a specific way, in which the colour above and below in the palette book is closest to the original colour. The application ended up matching the Peru (PPU1-18) to the Majestic Orchard (PPU1-1), which is the colour directly above of it in the palette book. The second closest colour match in this set was the French Silver (PPU18-5) and the Green Balsam (PPU11-15) with the ΔE$_{ab}$ of 10.97. Visually when looking at Figure 2, there is a substantial difference shown between these two colours, even just glancing with the human eye. The French Silver is a light grey, while the Green Balsam is a greyish green. Finally, the third match was the

FIGURE 5

A graphical representation of the ΔE$_{ab}$ for each of the wallpaper matches. The original data was gathered from the Behr Colour Smart Application, and the photos were taken on an iPhone 5s.
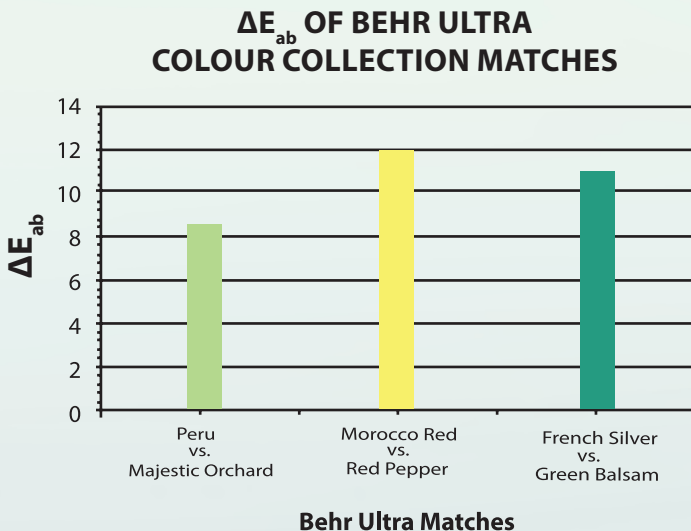

ΔE$_{ab}$ OF BEHR ULTRA COLOUR COLLECTION MATCHES

least exact with the ΔE_{ab} being the highest at 11.89. From knowing the ideal match numbers, it is easy to conclude that none of these matches would be considered fair matches, and therefore, would not be acceptable.

ΔE_{ab} OF MARQUEE EXCEPTIONAL PERFORMANCE MATCHES

The Behr Ultra Marquee matches were the most astounding, as two of them were exact matches. When photographing the Costal Jelly and the South Pacific swatches, the matches that the application was exactly what they should have been intended to be. The matches came up as their individual swatches; therefore, proving this application could be used as good reference for a colour match. The third match, however, with Rumors and Pompeian Red, did not create an acceptable match. The ΔE_{ab} was 14.95, which is unacceptable as a good match.

FIGURE 6

A graphical representation of the ΔE_{ab} for each of the tank top matches. The original data was gathered from the Behr Colour Smart Application, and the photos were taken on an iPhone 5s.

ΔE_{ab} OF MARQUEE MATCHES
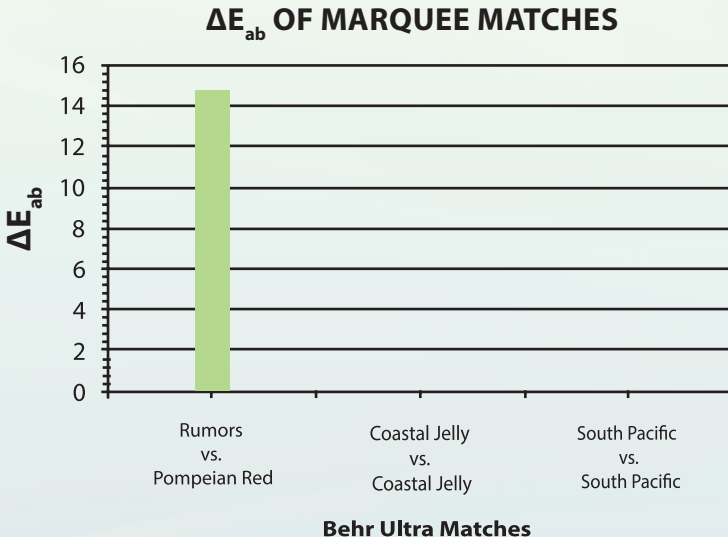
ANALYSIS

Based on the results of this investigation, it appears that the hypothesis was incorrect. The prediction that the application would not be able to make an exact match was surprisingly proven wrong. Further, the thought that the application would have struggled with glossier paper as there could be other factors affecting the colour of the photograph, like surface glare, ended up being incorrect as well. However, with the Marquee lookbook in Figure 7, each swatch had a spot gloss applied to it in order for the swatch to reflect the actual paint colour. The Marquee swatches ended up having the closest matches, with two perfect matches, so clearly, there are ways that the application compensates for this. Surprisingly, it was extremely exciting to realize that one of the wallpaper matches in Figure 6 was considered a good match, untraceable by the human eye.

Alongside exploring different colours, previewing them in different virtual rooms and creating a favourites list, the intended purpose of the application is to be able to correctly evaluate a photograph and produce an extremely close colour match. For the public, they may be unaware of exterior factors, which could interrupt the process of finding a perfect

match and could pose possible problems in creating this test on their own. The perception of colour is based solely on three things: the observer, the light and the object (BYK). If anything were to interrupt these elements, the colour would be skewed. Factors like this could include relativity, which is the perceived view of the colour based on the targets relation to the colours surrounding it (Munsell, 2013).

Throughout this experiment, all the photographs were taken in a controlled environment with proper D50 lighting. If a consumer was to take a photo of their wall, they may have elements that could interfere with the closest match, such as lighting, as well as the camera that the image was taken on. When uncovering why some of

the sets of matches were closer than others, taking into account of the make up of the substrate is also crucial. As Behr states, the application will do its best to match any photograph, but if someone took a photo of a liquid like a stream, the colours that would match could vary in many different shades and hues.

The two substrates that were printed recently on an expensive stock with various additives added to them like spot gloss and matte, contributed to the matches being closer. The substrate with the most differing matches was the wallpaper, which was older, and had several colours and shades within it.

Alongside of human error, other things had to be done in order for this experiment to

work properly. Firstly, all the images must be taken in a controlled environment, such as on a flat surface, so that the colour remains constant with no shadows. Secondly, the application must be up-to-date with the app version 2.0.17 in order for the results to be more exact. Finally, the X-Rite 530 Spectrophotometer must be calibrated and placed on a flat surface in order for it to work successfully.

There has been a strong emergence of colour match applications in the industry, similar to the Behr ColorSmart application. Behr is not the only paint company that is trying to tap into this field; companies like Benjamin Moore have also created virtual applications with the same purpose. PANTONE has created a colour match application as well, with the purpose of matching your images to their set of colours. While browsing the Apple App Store, there are lists upon lists of colour matching applications for a user to download and try out. Although technology, such as the use of these applications, is the future of the industry, the general population needs to be aware that these applications, however extraordinary, may not be as accurate as desired.

The purpose of this report is to advocate the accuracy of the Behr's ColorSmart application. Painting a home for some is a huge ordeal as people pay large amounts of money in order to make their home reflect

who they are. The appeal of this application is that inspiration for a home design can come from anywhere, and this application is helping people find the perfect colour for their home. The purpose of this report is to create awareness that the application should not be used solely as an exact means for colour matching. Though it is creative and can be used as general colour reference, the colours produced in this assessment were far from being correct matches. To summarize, only three out of the nine matches could be considered tolerable as an acceptable colour match.

CONCLUSION

In conclusion, with the emergence of colour matching technological applications, it is important to keep in mind that although the match may be similar, the technology has not been proven to be exact. Though the application claims it can accurately match a spot on an image to one of their vast selections of paint swatches, the match will not likely have an acceptable ΔE_{ab}. With the Behr ColorSmart application, the ΔE_{ab} was found more acceptable in professionally printed material.

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6

6

IS 1.0 DELTA E A JUST-NOTICEABLE DIFFERENCE?

By: Ayako Sato

ABSTRACT

This experiment is to test the validity of one well-known colour theory Just-Noticeable Difference (JND), which claims that 1 Delta E (ΔE) is the smallest colour difference that people can identify (Habekost, 2007). The testing process starts with creating tests forms using eight common descriptive colours, each colour required four sets of 14 patches. The colour difference between patches is set based on the minimum L*a*b* adjustment of Adobe Photoshop CS6 meaning one unit gap in either a* or b* value. These test patches are processed under the same condition through ColorBurst RIP, printed with EPSON Stylus Pro 4900 on Kodak Matchprint Pro Coated SM240P Media, Type 1. The L*a*b* values of each patch were measured using an X-Rite eXact Spectrophotometer with the setting was set at D50/2°, M1, and then the ΔE values were calculated using both ΔE_{ab} and ΔE_{00} equations. The sampled respondents were professors, staff members and students from the Graphic Communications Management (GCM) Department at Ryerson University. They certainly do not capture the demographic variations in the general population. The sample may bias the research finding in some way, however, it should strengthen the research finding. After all, the respondents are professionals and future professionals who have been trained in colour management. The JND for them should be even lower than the Just-Noticeable Difference at 1.0 ΔE. Survey data collected in this research, however, reveal strong evidence that JND ΔE is higher than one. The ΔE values are calculated using two different equations, ΔE_{ab} and ΔE_{00}, and this dramatically influences the result. The JND is much higher in the ΔE_{ab} scale compared to the result of ΔE_{00}.

EXPERIMENTAL SETUP

SOFTWARE

OS and software:
- iMac OS X Version 10.9.5
- iMac OS X Version 10.8.5 (ColorBurst® RIP 7.4)
- Adobe® Photoshop® CS6 Extended Version 13.0.6 x64
- Microsoft Excel 2010
- ColorBurst® RIP 7.4
- X-Rite eXact™ DataCatcher for PC Version 1.0
- Bruce Lindbloom's Online Color Difference Calculator

EQUIPMENT

- EPSON Stylus Pro 4900
- X-Rite eXact™ Portable Spectrophotometer

MATERIAL

- Kodak Matchprint Pro Coated SM240P Media, Type 1, 17 in. x 100 ft.

PROCEDURE

1. **Create test patches with eight descriptive colours using Adobe Photoshop CS6.**

Each square patch contains two parts that are split in the center. See Figure 1 for an example. The left side is filled with descriptive colours (from Table 1), in which the values are consistent in all patches. The colour of another half varies. Photoshop only allows adjusting the L*a*b* values before the decimal point; therefore, each change is one increment or decrement of a* or b* value. There are a total of 448 patches that were prepared for this experiment. This contains eight descriptive colours, four sets per colour, and 14 patches per set. The Photoshop native files are saved as a TIFF file using default setting.

FIGURE 1

Example of a test patch.

Fixed Colour Values	Variable Colour Values (± 1 a* or ± b*)

TABLE 1

List of the descriptive colour names and their L*a*b* values in Photoshop native files.

NAME	L*	a*	b*
Skin	74	18	21
Gray	50	4	4
Yellow	84	2	90
Sky	63	-33	-44
Orange	56	67	67
Blue	33	2	-42
Red	48	66	43
Green	52	-65	15

2. **Print patches using ColorBurst RIP 7.4 and EPSON Stylus Pro 4900 on the Kodak Matchprint Pro Coated stock**

All patches are printed using the same printing device on the same substrate under the same RIP setting, which is shown in Table 2. The L*a*b* value of each patch is measured in the later stage of the procedures and ΔE is calculated based on the measured values. This means that this process becomes less significant and rather to retain printing quality consistent.

TABLE 2

ColorBurst RIP Setting.

ENABLE ICC COLOR MANAGEMENT: ON	
Input Profile	• ROB Image: ColorBurst ROB.ice - Perceptual • CMYK Image: EP49K_D50_I 50128.icc - Absolute Colorimetric • Gray Image: Gray Gamma 1.8.icc - Perceptual • Black Point Compensation: Off • Use Embedded Profiles: On
Output Profile	• CMYK Profile: EP49K_D50_ I 20128.icc • Simulation Profile: None

3. **Measure the CIELAB values of entire patches using the X-Rite eXact Portable Spectrophotometer.**

The spectrophotometer is set at D50/2°, M1. CIELAB is one of the human-vision based colour metrics, which is established by Commission Internationale de l'Eclairage (CIE). Human colour perception is influenced by three components – the light source, the object and the observer (Adams II, Sharma, & Suffoletto, 2008).

To test the human colour perception accurately, this study uses light sources approved by CIE. D50 (5000K), which theoretically represents daylight, is one of the standard light sources and it is used as the setting of the spectrophotometer to obtain L*a*b* value, as well as the lighting condition during testing with observers in this project (Adams II, Sharma, & Suffoletto, 2008).

Another important aspect of perception is the observer. 2° field of view is based on the idea that colour sensitive cones are concentrated within the 2° arc of the fovea in human eye (HunterLab, 2008). CIE conducted experiments to quantify the standard observer based on the 2° field of view and developed 1931 (2°) Standard Observer, which was used for the project (X-Rite, 2014). The last setting, M1, is to reduce the measurement variances due to fluorescence from brighteners in paper or imaging/proofing colourants (Cheydleur & O'Connor, 2011).

DataCatcher is downloaded to a computer, which is connected to X-Rite eXact Spectrophotometer and the L*a*b* measurements are directly inputted in the Microsoft Excel file.

FIGURE 2

Photo of an L*a*b* value measured by the X-Rite eXact Spectrophotometer.

4. Compute ΔE$_{ab}$ and ΔE$_{00}$ values.

Formulas:

$$\Delta E_{ab} = \sqrt{\left(L^*_2 - L^*_1\right)^2 + \left(a^*_2 - a^*_1\right)^2 + \left(b^*_2 - b^*_1\right)^2}$$

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T \frac{\Delta C'}{k_C S_C} \frac{\Delta H'}{k_H S_H}}$$

The L*a*b* values obtained in step 3 are then used to calculate both ΔE$_{ab}$ and ΔE$_{00}$ values. ΔE$_{ab}$ is computed by formulating excel sheet while ΔE$_{00}$ is calculated using Bruce Lindbloom's Online Color Difference Calculator. Further aspects regarding these two different ΔE equations are discussed in the later section of this report.

5. Cut out the patches and paste them on a large black backing sheet. Also, prepare ten sets of answer sheets with a question sentence.

There are a total of 16 test sheets that are prepared; two test sheets per descriptive colour, and their layout can be seen in Figure 3. 14 patches are organized in order; there is one increment or decrement of Photoshop's a* or b* value between the patches.

The key question asked in the survey questionnaire is "Please write down the number of a patch in which you just start to see the colour difference." The survey questionnaire asks respondents the basic individual identifier questions (including name, signature, survey date, gender and age) and whether they have any colour deficiency.

FIGURE 3

Test sheet given to respondents.

6. Conduct tests with ten observers.

The experiment is conducted in the basement of the Heidelberg Building at Ryerson University – the HEI010 Press Lab using two D50 lighting booths. Ideally, the test should be conducted using one lighting booth. Given the constraint of resources, it is assumed that the two lighting booths were set in the same conditions. Any bias caused by the differences in the lighting booth is negligible. Each individual goes over the 16 test sheets created in the step 5 and writes down the patch numbers where they just start see the color difference on the answer sheet.

7. **Sort out the results by colours using Microsoft Excel. Then calculate mean, standard deviation, margin of error, lower bond and upper bond to create statistical graphs.**

Due to the limitation of Photoshop, which only allows L*a*b* adjustments before decimal point, both ΔE_{ab} and ΔE_{00} values are rather random (the colour difference between each patch is not consistent, not the same intervals) and this leads a problem during the creation of the graphs. When directly plotting the raw data into a graph, with the number of counts (one count is when an observer identifies the particular patches as JND) as the dependent valuable (Y-axis) and with the ΔE values as the independent valuable (X-axis), the number of patches/ΔE values is inconsistent between each interval on the X-axis. The more the patches exist between the intervals, the number of counts increases. As a result, the graph created in this way cannot represent the result accurately. In order to solve this issue, a statistical analysis is required before creating the graphs. The following information and formula under "Formulas" are used for the statistical analysis as seen in Table 3.

Margin of error determines how reliable the data set obtained from a sample when making inference about the general population. Based on the margin of error, the confidence interval for the average JND can be calculated (Kalla, 2009). This study uses the 95% threshold, which can be interpreted as "a range of values that you can be 95% certain contains the true mean of the population" (GraphPad Software, Inc., 2015).

Formulas:

$$Standard\ deviation = \sqrt{\frac{\sum_{i=1}^{n}(X_i - X)^2}{n-1}}$$

$$Margin\ of\ error = Z^* \frac{\sigma}{\sqrt{n}}$$

Lower bond = Standard deviation – Margin of error

Upper bond = Standard deviation + Margin of error

TABLE 3

Statistical analysis information.

	SAMPLE SIZE	CONFIDENCE INTERVAL
Single Colour	**40** Ten Observers Four sets per colour	**95%**
Entire Colour	**320** Ten Observers Eight colour Four sets per colour	**95%**

RESULTS

TABLE 4

Lower and upper bond, mean and range of the ΔE_{ab} of the descriptive colours.

ΔE_{ab}				
Colour	Lower Bond	Mean	Upper Bond	Range
Skin	2.13	2.44	2.75	0.62
Gray	1.61	1.83	2.05	0.44
Yellow	4.56	5.81	7.07	2.51
Sky	2.72	3.29	3.86	1.14
Orange	4.65	5.79	6.93	2.28
Blue	2.15	2.45	2.75	0.60
Red	4.30	4.86	5.40	1.10
Green	4.03	4.80	5.57	1.54
Entire Colours	**3.60**	**3.90**	**4.21**	**0.61**

TABLE 5

Lower and upper bond, mean and range of the ΔE_{00} of the descriptive colours.

ΔE_{00}				
Colour	Lower Bond	Mean	Upper Bond	Range
Skin	1.43	1.63	1.83	0.40
Gray	1.74	1.96	2.18	0.44
Yellow	1.39	1.59	1.79	0.40
Sky	1.06	1.29	1.52	0.46
Orange	1.97	2.38	2.79	0.82
Blue	1.15	1.38	1.60	0.45
Red	1.73	1.97	2.20	0.47
Green	1.38	1.59	1.79	0.41
Entire Colours	**1.63**	**1.72**	**1.82**	**0.19**

ΔE_{ab} VS. ΔE_{00}

The biggest difference between ΔE_{ab} and ΔE_{00} is how they weight the three colour axis – hue, chrome and lightness. ΔE_{ab} equation weights the three axis equally, whereas ΔE_{00} weights them differently. In general, ΔE_{00} values match more accurately to the human colour perspective than ΔE_{ab} does (Flexographic Technical Association, 2013). The idea that the ΔE of 1.0 is JND was based on the ΔE_{ab} equation; however, the equation did not include the consideration of the three colour axis. Therefore, it was hard to prove that 1.0 ΔE is a JND. It is because the human eye is not evenly sensitive to the wavelength and the visible colour difference varies depending on the colour (Habekost, 2007).

The results of ΔE_{ab} shows the smallest mean value, which is 1.83 ΔE of gray; in contrast, the largest mean value is 5.81 ΔE of yellow. This means that identifying the colour difference is easier in gray compared to yellow. Another finding regarding ΔE_{ab} is that the colours with high positive b* value – yellow, orange, red and green – have difficulty in noticing the colour difference, and the means of all four colours are above 4.75 ΔE. Compared to these vibrant colours, natural colours such as skin tone have means that are relatively low, meaning people are more sensitive to colour difference in the neutral area.

Furthermore, when evaluating the range of the ΔE_{ab} results, which are represented as the lengths of vertical strokes in the following graph, they vary depending on colour. For example, comparing yellow to gray, the range of yellow is a 2.07 value wider than that of gray. On the other hand, the result of ΔE_{00} shows the sense of consistency; the means of almost all colours are between 1.25 to 2.0 ΔE, except for orange. This represents that ΔE_{00} is not influenced by the colour hue difference as

much, while ΔE_{ab} is. Also, the consistency can be observed by comparing to the range of ΔE_{00} to ΔE_{ab}. The overall variance is much smaller as the ranges of seven colours remains between 0.40 to 0.47, while orange has a high range of 0.82.

IS 1.0 ΔE A JUST-NOTICEABLE DIFFERENCE?

Although the concept "1 ΔE is JND" was based on the ΔE_{ab} scale, the result of ΔE_{ab} shows that people notice colour difference when ΔE is much higher than 1.0. The average JND is 3.9 ΔE when looking at the all the samples. One of the factors can be that the ΔE_{ab} excluded weighting the three colour axis. The variance in the means of ΔE_{ab} is significant, and the level where people see the colour difference is influenced depending on colour or hue. The mean of the entire colour on the ΔE_{00} scale is 1.72 and much smaller when compared to ΔE_{ab}; however, it is still higher than 1.0 ΔE. Sky blue has the lowest mean of 1.29 ΔE in the ΔE_{00} results, and also, the value is the smallest in the entire result. Possible reasons for this finding, which the JND is higher than 1.0 ΔE, can be how the test form was prepared. The colour patches are placed on the black backing sheets and this creates a high contrast between the patches and their surroundings. During the experiment with observers, many mentioned about some sort of discomfort with their eyes due to the high contrast, especially with red and orange patches. This shows in the result that the red and orange obtains the highest means.

CONCLUSION

In colour management, 1.0 ΔE has been recognized as the barely visible colour difference. Data collected in this study, however, reveal evidence that the JND is higher. At the initial stage of the project, the expected outcome was that JND would be a ΔE value lower than 1.0 because the selected observers were trained in colour management. After conducting this experiment, the findings are completely opposite from the initial expectation, as the JND ΔE value is actually higher than 1.0.

The key findings of this project are how the ΔE is calculated and influences the JND ΔE value. Firstly, ΔE_{ab} and ΔE_{00} equations produce significantly different ΔE values, although it is calculated based on the raw L*a* b* value. Secondly, ΔE_{ab} can vary depending on the colour, and it is because the equation does not weight the hue, chrome and lightness. The results calculated using ΔE_{ab} equations shows people are less sensitive to vibrant colours, especially colours with high positive b* value. Thirdly, the result of ΔE_{00}, which is believed to be a better match with human colour perspective, has less influence from hue difference and the JND ΔE values are somewhat consistent through colour. There would be many possible factors that influence how well people see the colour difference. However, 1.0 ΔE may not be barely visible colour difference and actual JND value is higher than 1.0.

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THE GENERAL MEMBER EXPERIENCE

"Becoming a RyeTAGA General Member in first year was one of the best decisions I have made in university thus far. It has been an excellent networking opportunity and learning experience. I look forward to being part of RyeTAGA in years to come."
- Susan Hanna, 2nd Year

"From the get-go, RyeTAGA has offered a fun and rewarding experience to work with both new and experienced members! It's always satisfying to be a part of a group that puts together a tangible project that combines artistic skills and production knowledge with real teamwork and leadership."
- Logan Nash, 4th Year

"RyeTAGA was overall an interesting and good experience. Although I had a very small role, it was nice to meet older students, get to know them, and ultimately learn from them."
- Samantha Chung, 1st Year

"I am very fortunate to be a part of the RyeTAGA student chapter. It is my first year participating as a general member, and the team has been extremely welcoming. I look forward to contributing to the creation of the 2016 Journal!"
- Anastassia Trofimov, 2nd Year

"RyeTAGA was a common word passed around by fellow students when I first started Graphic Communications Management. Now in my third year, I've decided to join and find out about the team and its process on creating a journal. When meeting the team, I've noticed the opportunities and passion the members exhibited in order for general members to feel comfortable and ready to include themselves in this project. I hope to learn the process in creating a journal through the RyeTAGA team to better develop my personal skills."
- Jessica Rocha, 3rd Year

"I've been a general member since first year orientation and the RyeTAGA student chapter never fails to amaze me with all their accomplishments within the printing industry. I wish that I had taken more opportunities with RyeTAGA from the start of my university experience, but I hope I can become active in helping with the journal production process and projects in the future!"
- Christina Phan, 3rd Year

DIONDRA FILICETTI

CO-PRESIDENT

For me, being a part of RyeTAGA has been less about gaining knowledge and more about working with a variety of people who possess different skills. The technical knowledge I learned was critically important and being part of RyeTAGA has enhanced my education in the School of Graphic Communications Management. It facilitated my ability to identify the consequences and implications of various materials and processes on our journal, events and deadlines. However, the most valuable learning experience was exploring the potential and harnessing the abilities of a team of eight and leveraging the resources available to create a journal that we are proud of. Above all, it was personally satisfying being able to engage students to create an inclusive, supportive RyeTAGA community.

JESSICA TAM

CO-PRESIDENT

Personally, being a part of RyeTAGA has been a great experience. It has made me grow as an individual, a leader and a team player. RyeTAGA, so far, has given me great opportunities for me to apply all the knowledge learned in class. I can't wait to continue to improve and grow with the team and meet amazing new people throughout this journey. All in all, RyeTAGA has been a memorable part of my second year in the Graphic Communications Management program and I wish to always be a part of this team in the future in any way possible.

JAMES LAI

CREATIVE DIRECTOR

As a third year student in the Graphic Communications Management program, I am excited to take on the role of the Creative Director in RyeTAGA. With this experience, I seek to grow as a professional individual and develop a skill set that will set me above from the rest. This year I will strive to breathe life into a journal that will set the legacy of RyeTAGA in stone. With the creation of this journal, I hope to inspire more people to take on positions in RyeTAGA and continue the legacy passed down from those who aspired for perfection before us.

James Lai

JASMINE KEO
PRODUCTION/EDITORIAL DIRECTOR

Entering my fourth and final school year at GCM, I joined RyeTAGA because I wanted to become more involved with this great organization to enhance my academic experience and to take this opportunity to utilize and further my knowledge and skills that I have gained during my time at GCM. I am also thankful to be working with a strong team of diverse skills. As the Production/Editorial Director, I want to continue RyeTAGA's tradition of delivering the best journal that we can possibly produce. I look forward to seeing this journal come to life from beginning to end.

VANESSA BLUM

FINANCIAL DIRECTOR

As a fourth year student, I feel incredibly lucky to be part of the RyeTAGA 2015-2016 executive team. Working on this year's journal will be a chance to complete a project that utilizes the skills I have attained in the last three years. I am excited to work with a select group of students and showcase our talents to leaders in the graphic arts industry.

ANTHONY KRYSTECKI

MARKETING DIRECTOR

The task of writing a small paragraph about my experience with RyeTAGA just isn't doing it proper justice. Though my time with RyeTAGA has been brief, it has really been a journey so far, allowing me to use my education to the fullest, apply concepts and techniques learned in class in contexts I never thought I would need them. Needless to say, I have greatly enjoyed my time on this team so far and look forward to what the new year holds in store for us.

KIM SIPKENS

CORPORATE RELATIONS DIRECTOR

As a fourth year student, I feel incredibly lucky to have been given the opportunity to work with such an outstanding team who have exemplified their diverse skills throughout the completion of the technical journal. This project allowed me to follow a product through its production life cycle from beginning to end, developing a greater understanding of the processes involved in the Graphic Arts industry. The motivation and enthusiasm that continued to grow throughout the year amongst the team was inspiring. It never fails to amaze me how much a team is capable of and how much can be accomplished when you play to each member's strengths.

NATALIE MAINVILLE

MULTIMEDIA DIRECTOR

RyeTAGA became a part of my life at the beginning of my seventh semester at Ryerson University and I'm very glad it did. RyeTAGA has allowed me to combine professional, academic and creative skills within a team environment. I've always been the type of individual who loves getting involved in extracurriculars such as sports or social teams, however, this is my first academic student group which has challenged me and allowed me to be part of an amazing team of unique and talented individuals. RyeTAGA has opened new doors of opportunity and has been a key component in solidifying my knowledge learned in class work and lectures from my major in Graphic Communications Management. Becoming part of the RyeTAGA community has been a rewarding and eye opening experience and I look forward to what the future has in store for both myself, the team and future members.

SCOTT MILLWARD
FACULTY ADVISOR

As a former RyeTAGA student member, being asked to be the faculty advisor was an honour and a new experience. I've been grateful to have the opportunity to work with a group of people that are dedicated to the goals of the chapter. All the executive and members are enthusiastic members of the team and it has been a pleasure working with them.

2015 - 2016 EXECUTIVE TEAM

COLOPHON

TYPEFACES

Avenir
BigNoodleTitling
Bebas Neue
Myriad Pro
Palatino

INKS

HP Indigo's Liquid ElectroInk, UV Raised Ink
Océ UV Cured Inks, Océ IJC 261 UV Ink

STOCKS

Supreme Silk 80lb Text
PET/LM Brushed Metal from Trans-Kote
McCoy Silk Cover 80lb

SOFTWARE & EQUIPMENT

Adobe Creative Suite 6
Kodak Preps 6
Xerox FreeFlow
Xerox 700 Digital Press at Ryerson University
Océ Arizona 6170 XTS at Global Imaging
GBC Professional 3064 WF at Global Imaging
HP Indigo 7800 at DT Print Solutions

BINDING & FINISHING EQUIPMENT

Kongsberg-XP at Global Imaging
Stahl Folder 1220E at Ryerson University
Polar 78 Cutter at Ryerson University
Muller Martini Amigo Perfect Binder at Ryerson University

FINAL ACKNOWLEDGEMENTS

Sometimes we are so focused on the destination, instead of appreciating the journey. RyeTAGA is not just about creating a spectacular journal, it is about the small details and the experiences that went into creating this journal.

What has been most valuable to us is that each and every single member (whether executive or general member) has completed this journal with more knowledge, more contacts and improved skills, which will be undoubtedly beneficial on future projects and in a career setting.

The 2016 RyeTAGA journal would not have been possible without the efforts of our key members. This journal and this experience would not have been a success without our RyeTAGA community which includes our general members, the GCM faculty and staff, and our sponsors. This community both inspires us and propels us forward to continue and thrive to do better.

We are forever grateful. See you next year.

Thank you.

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