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Graphic Communications Management

GCM490- Thesis

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The Analysis of Skin Tones and How They are Replicated in Commercial Offset Lithography

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The Analysis of Skin Tones and How They are Replicated in Commercial Offset Lithography

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Abstract

This thesis is a study surrounding a seemingly unexplained phenomenon within the print industry. Skin tone colours are specifically known to be more difficult or temperamental when printing them in a commercial setting. This study delves into the reason or reasons why this may be happening and gives some context as to where this sentiment could come from and how it can be dealt with. This thesis makes use of the powerful colour plotting tool, ColorThink Pro, to examine the colour makeup of skin tones and discuss why they specifically can be harder to replicate.

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Introduction

The goal of this research is to affirm the idea that skin tone colours are not in fact ‘difficult’ to print, but are actually well within the standard GRACoL colour gamut and can be printed easily so long as your press is properly calibrated. This thesis delves into the world of skin tones in colour management, and analyzes commonly used test and calibration images that are used throughout the industry. This is to give a sense of what is currently being used to calibrate and manage the colour of skin tones in a commercial print setting so that some further information can be extrapolated about how skin tones act within colour management for print.

Literature Review

The reproduction of skin tones in print and photography have been a point of interest for decades, it is like a trade secret and common enemy amongst print and colour management operators how skin colours should be printed and calibrated correctly, as the usual fool-proof colour management methods do not always work. This has led us to believe that skin tones are more difficult to get to look right and you have to put in an extra effort to replicate them accurately.

What are these colours and how do we define them?

Before we can analyze the way skin colours are being reproduced, we must define how colour is examined and defined within industry, and where specifically skin colours fall into that definition. For the purpose of this thesis and its research method for studying skin tones, it is important to define and explain some crucial topics. Since this study focuses more on general industry-wide circumstances, it was important to acknowledge that offset lithographic printing would likely be the printing method used to replicate these skin tones, whether it be for magazines, posters, brochures or any other product that would have images of people on it. GRACoL is the General Requirements for Applications in Commercial Offset Lithography, which is a standardized set of specifications that was created by Idealliance to aid in the colour regulation of offset lithography (GRACoL®, 2020), so GRACoL plays an important part of the colour management of offset lithographic printing, therefore playing a key

part in this study. In regard to how we quantify colour, there are a number of different methods and equations that can be used. The most commonly used for purpose of this thesis is the CIE L*a*b* colour space. L*a*b* shows the colours by L*= lightness, a*= green(-) to red(+), and b*= blue(-) to yellow(+) (Sharma, 2018); meaning that each colour is given independent numbers to quantify exactly what the colour is and can be visualized easily. Therefore, the colours are easier to analyze using this colour space and allows it to be easily compared to the GRACoL colour gamut.

Historical context

Test Images and Targets

The test images that are commonly used in industry generally include photos of specific items or people that are used to match colours after they are printed, and the test targets are usually a series of colours arranged in a grid that are used as samples to calibrate colour profiles as well as be used visually as a colour reference. Skin tones specifically are one of the requirements for what should be included in the test photos considering the importance of getting skin tones to look right. Skin tones are generally neutral colours so we notice it more when the colours are too red, too green, etc. We are more accustomed to seeing skin tones since we see them in our everyday lives, and we often pay more attention to people than we do other objects, so it is easier for us to notice when they do not look right, especially in a printed image. Skin tones are also useful for figuring out issues with the colour management process, since we are able to notice the problems of the colours more easily on them. So, when we see images of people, since we are so accustomed to seeing them all the time, we notice it more when the colour of their skin does not look the way it should. Thus, when looking at test images and targets, the inclusion of multiple skin tones is very important for overall colour management (Ashe, 2014).

Shirley Cards

Something that has historically had a big impact on the way skin tones are photographed and the way colours are interpreted into print have been the use of images such as Shirley cards. The original Kodak Shirley card was an image of a woman named Shirley Page, who was a model for Kodak at the time, that was used by photo reproduction labs as a reference image for what the colour of skin tones

were meant to look like when printed from the camera (Del Barco, 2014). The problem with this was that the original “Shirley” card and subsequent replacement Shirley cards were always images of conventionally attractive Caucasian women, usually with blonde hair. This turned into a deep rooted colourism and perpetuation of a white western beauty standard that seeped into photography and print (Roth, 2009).

Figure 1 *This is the image of the original Shirley Card, made by Kodak*

Source: Roth, 2009

Why would skin tones be difficult to print?

Racial Bias

Since photography and thus print has had such an innocuous relationship with the way non-Caucasian skin tones are being reproduced, whether it be from the use of Shirley cards or other colour targets that are not diverse, it can lead many to believe that non-Caucasian skin tones are simply more difficult to photograph and print since this technology has historically not been made in their favor with their skin in mind. These Shirley cards were often considered “normal” or the standard for all skin tones, to the point where if a Caucasian person and an African American person were together in a photo, the photo would always print out over or under exposed, as there was no reference for diverse images and contrast of skin tones (Del Barco, 2014).

The Nature of Skin Tones

In addition to the aforementioned Shirley cards and history of racial bias within skin colour reproduction, what other influences can be involved with this notion of difficulty regarding skin tones specifically? To put it simply, it is likely that we just have a lower tolerance for when the colours are not printed correctly (Trimingham, 2017). Chances are that if we saw a printed picture of some flowers that was a little bit too green, we may not notice it, but if that image had people in it, we would notice the green in their skin immediately. This phenomenon has been discussed by various professionals in the field, which is why skin tones are considered important for colour management and are specifically used as a reference for accurate colour measurement. In the section about Delta-E (pg 120), of Understanding Colour Management Second Edition by Abhay Sharma, Sharma touches on the idea that we are more sensitive to certain changes in colour. So, for images that are highly saturated in colour, if a colour change is made, it is less noticeable than if that same change was made to desaturated 'neutral' areas including skin tones. This means that the Delta-E (change in colour) can have different amounts of impact between different types of colours, but ultimately skin tones are more susceptible to having a higher visual change in the way they look. This also connects to the idea that skin tones are more difficult to print since it is clear here that they visually show the change or colour error more noticeably than other colours. The likely reason why is because they are very neutral colours. If the balance of the colours in a press is just slightly off it can become very noticeable on the skin tones (Ashe, 2014).

Methodology

The main method to take a closer look at the reproduction of skin tones was to use the colour mapping program, Chromix ColorThink Pro 3.0.8 to show the GRACoL 2013 colour gamut in relation to some sample skin tone reference targets and images that are commonly used in industry.

Since GRACoL is a widely used industry standard, it would only make sense to use that as a colour reference. So, the GRACoL 2013 ICC profile was downloaded from the Idealliance website to be used in this study. An ICC profile is a file of data that is used to quantify a colour space and it shows all of the possible colours that can be

seen or used within that colour space or gamut (Enoksson, 2005). In this instance, the GRACoL colour space was used as a reference to show the average CMYK colour capabilities of an offset lithographic press that could then be compared with some sample skin tone colours.

To do this analysis, the sample test charts and photos were acquired from a variety of different companies to give a range of what is being used in the industry. There were five total images that were sampled for this analysis. These were the Kodak Ektacolor IT8.7/2-1993 target, Fujicolor IT8.7/2-1993 and the Agfacolor IT8.7/2-1993. The other two images that were analyzed were a GMG test photo and a general use ISO 300 test photo. The images were found from their respective company's website and were available for public use. The only exception was the GMG image, as their image required permission to be granted for use. Once acquired, the images were cropped using Adobe Photoshop 2020 to focus specifically on the skin tones so that the colours can be examined more accurately. For the images of people, the photo was cropped to focus on their faces, and for the IT8 photos, only the squares with the skin tone colours in them were used. Each image was processed using the sRGB IEC61966-2.1 colour profile in Photoshop so that they can all be compared on the same level.

To put everything together, ColorThink Pro was then used to plot the colour data. It can be done in a 2D or 3D space, using L*a*b*, Yxy or L*u*v* axis to show the data. For the purpose of this research, L*a*b* colour space was chosen to be used, and the colours were looked at in both 2D and 3D colour space. Once these specifications were chosen, the cropped versions of the test images were then put into ColorThink Pro along with the GRACoL colour profile to be used as a comparison.

Additionally, the cropped test images were pulled again into ColorThink Pro so that all the individual colours in each image could be quantified in a list, in this case they were listed in CIE L*C*h Color Space so that the colours could also be plotted showing the range of hue angles so the variation of the hues in the skin tones can be seen.

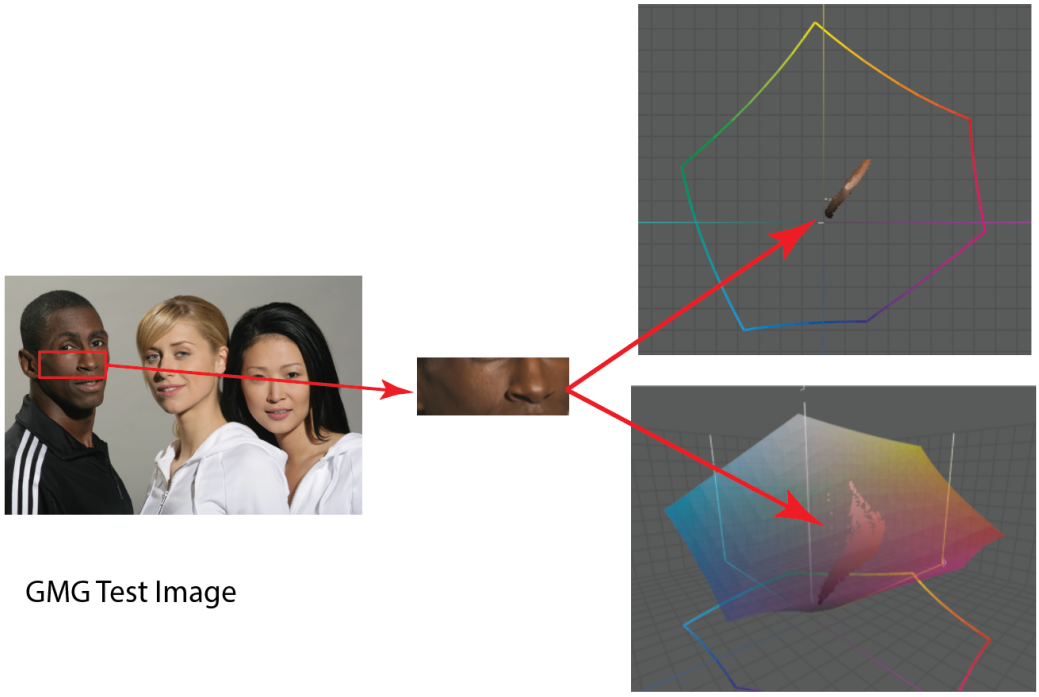


Figure 2 *This shows the process of taking a sample area of African American skin tones from the GMG reference image and plotting it in ColorThink Pro.*

Source: GMG. Replicated with permission from GMG.

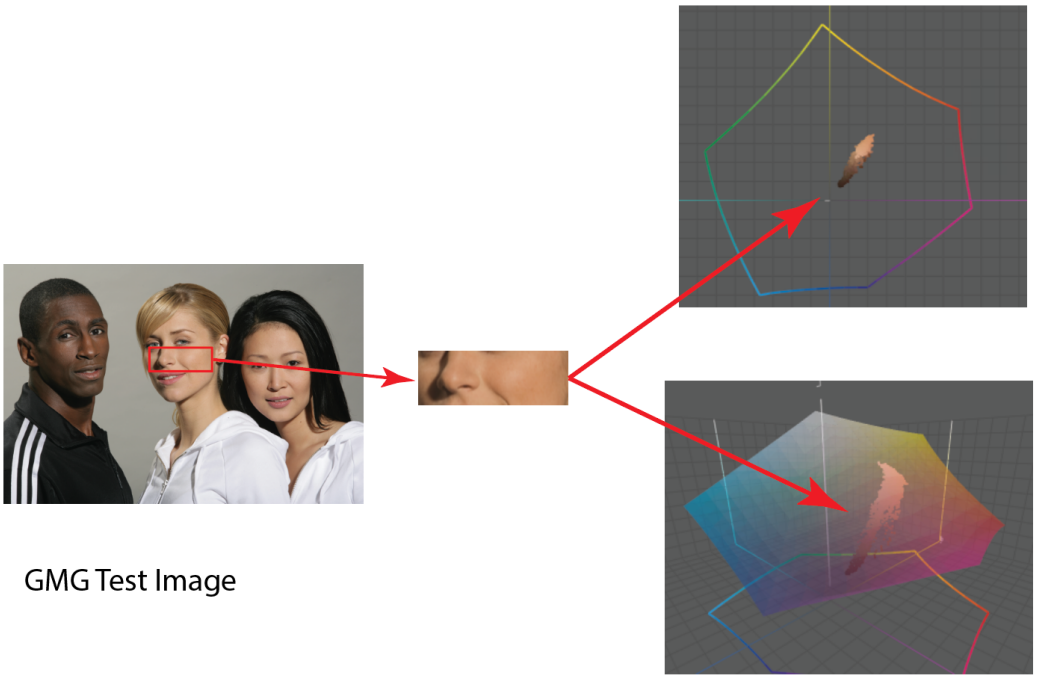
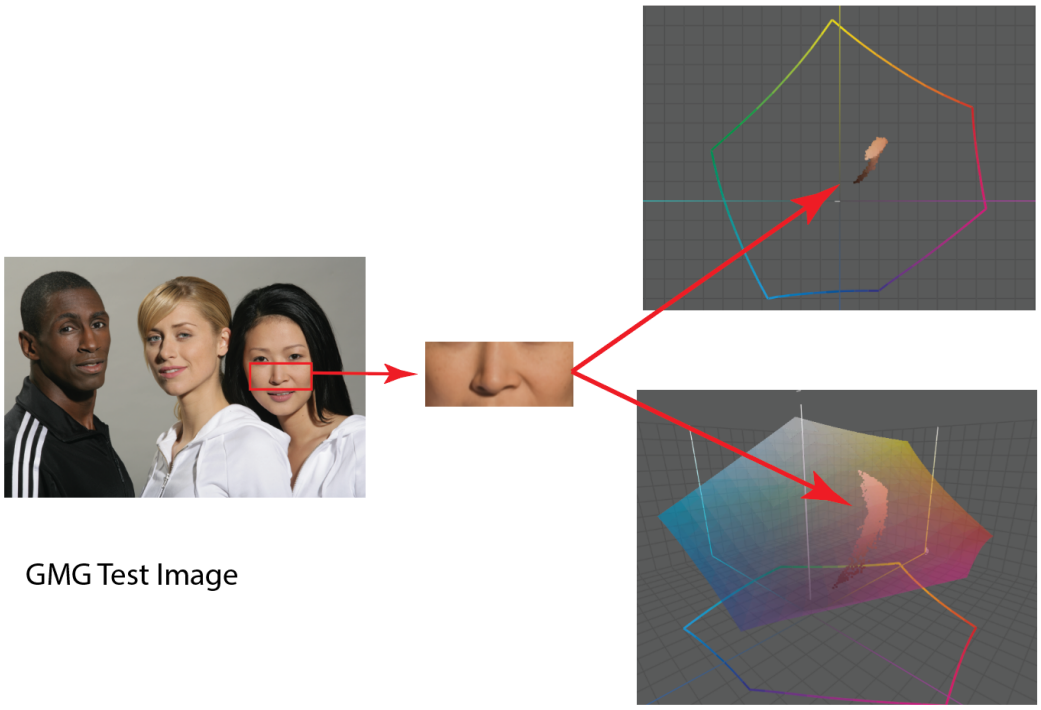


Figure 3 *This shows the process of taking a sample area of Caucasian skin tones from the GMG reference image and plotting it in ColorThink Pro.*

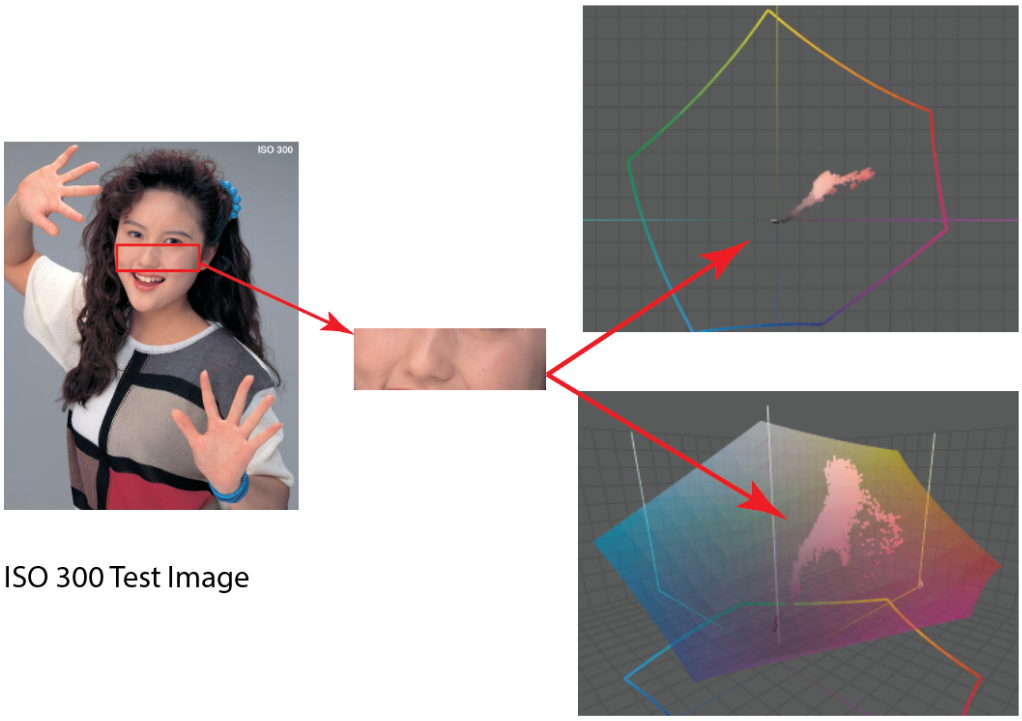
Source: GMG. Replicated with permission from GMG.



GMG Test Image

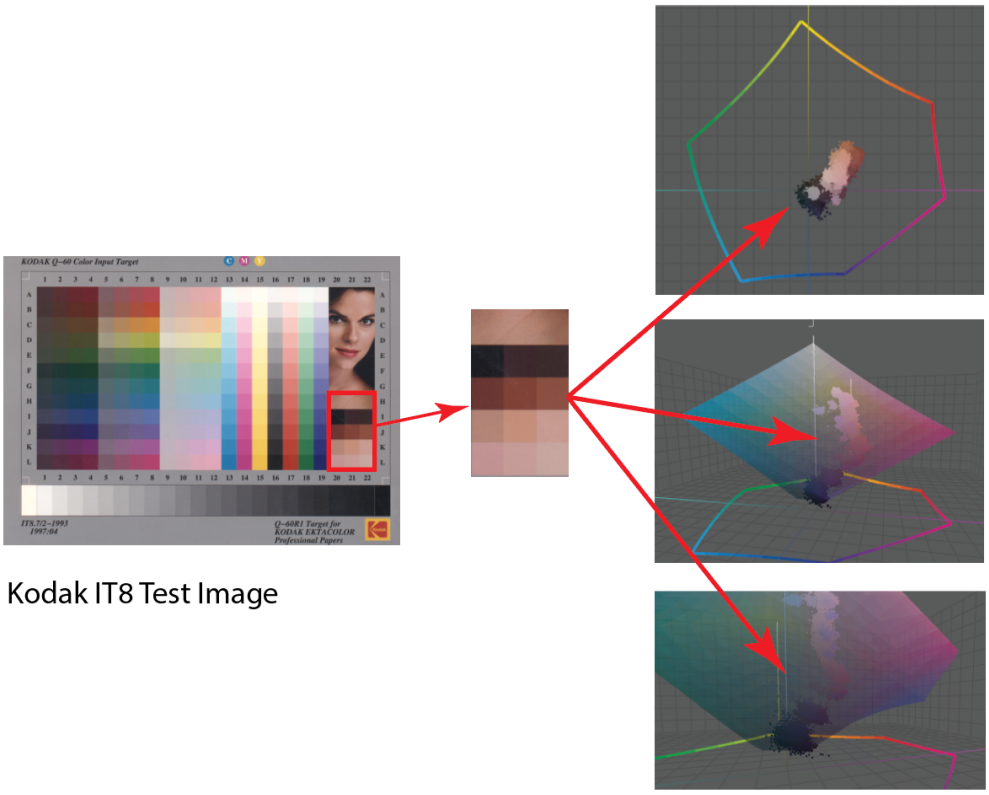
Figure 4 *This shows the process of taking a sample area of Southeast Asian skin tones from the GMG reference image and plotting it in ColorThink Pro.*

Source: GMG. Replicated with permission from GMG.



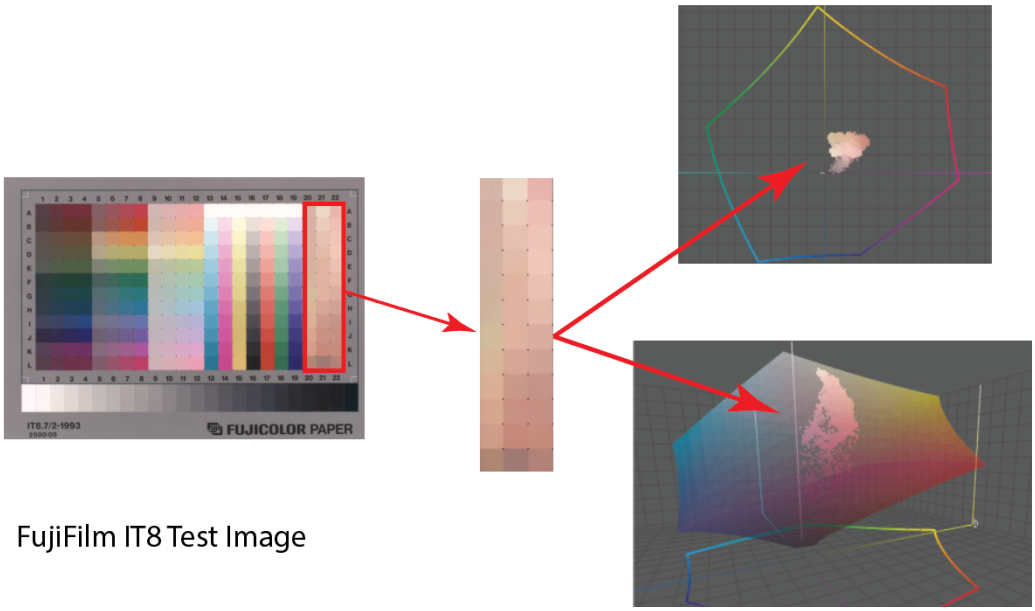
ISO 300 Test Image

Figure 5 *This shows the process of taking a sample area of skin tones from an ISO300 IT8 test image and plotting it in ColorThink Pro.*



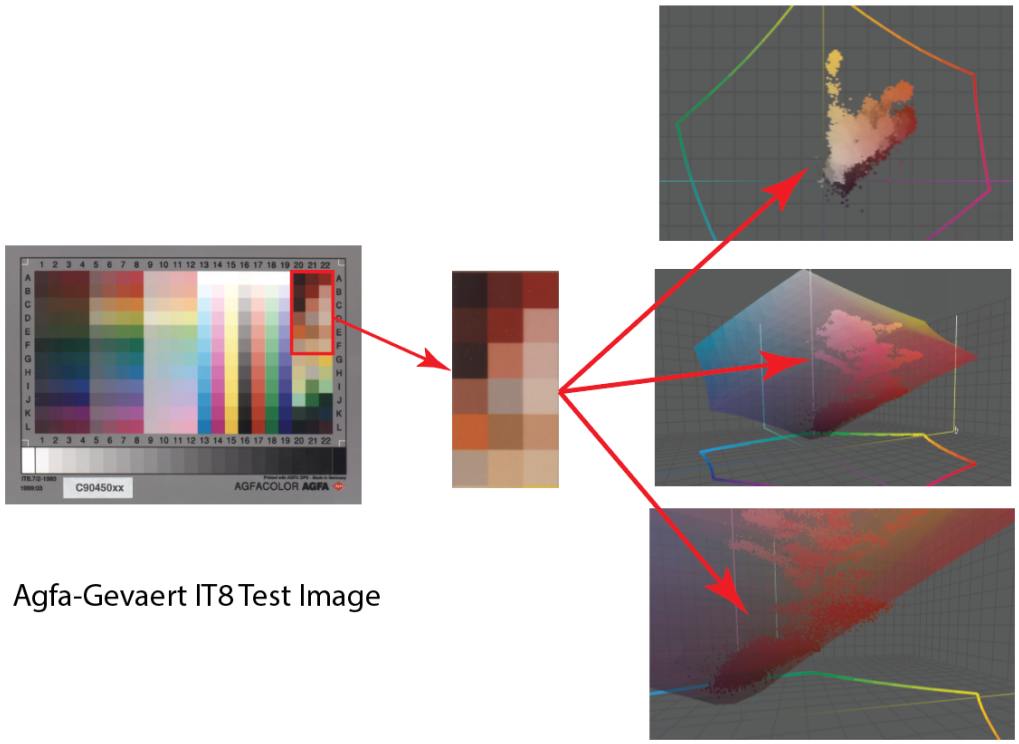
Kodak IT8 Test Image

Figure 6 *This shows the process of taking a sample area of skin tones from the Kodak IT8 test chart and plotting it in ColorThink Pro.*



FujiFilm IT8 Test Image

Figure 7 *This shows the process of taking a sample area of skin tones from the FUJICOLOR IT8 test chart and plotting it in ColorThink Pro.*



Agfa-Gevaert IT8 Test Image

Figure 8 *This shows the process of taking a sample area of skin tones from the AGFACOLOR IT8 test chart and plotting it in ColorThink Pro.*

Image	***Highest Hue Angle***	***Lowest Hue Angle***	***Average Hue Angle***
Caucasian woman from the GMG image	64.68°	44.71°	57.40°
Asian woman from the GMG image	61.77°	43.60°	55.11°
African-American man from the GMG image	83.98°	38.45°	55.59°
ISO300 image	358.03°	2.24°	36.18°
Fuji IT8	359.68°	1.24°	46.36°
Kodak IT8	359.96°	0.00°	61.34°
Agfa-Gevaert IT8	359.98°	0.00°	48.55°

Figure 9 *This chart shows some of the key data points that were taken from ColorThink Pro. The full data sets can be accessed in appendix 1-7.*

From the results of plotting the images in ColorThink Pro, we can deduce that all these standard images are well within the GRACoL 2013 colour gamut, meaning that they should be easy to reproduce.

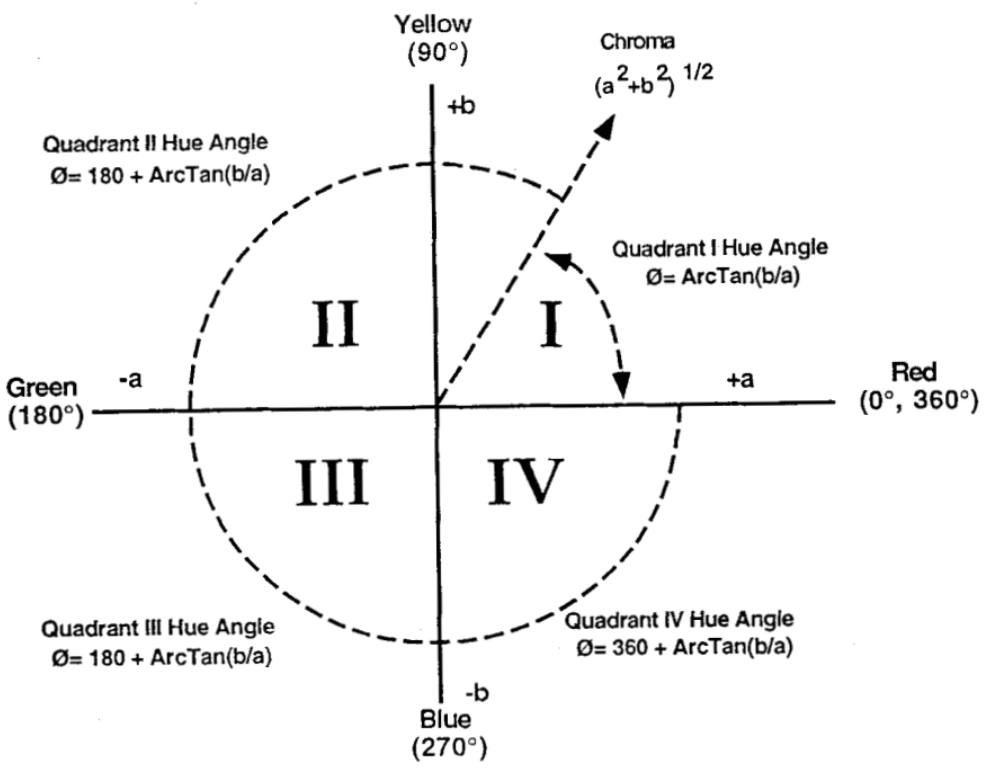


Figure 10 *This is a diagram of the colour spectrum in L*C*h*

Source: McLellan, 1994

Results

A great way to look at the results is by examining the hue angles of the different skin tones. When referring to hue angles, it is referring to a representation of colour on a 360° axis, where red is 0° and 360°, yellow is 90°, green is 180°, and blue is 270° (McLellan, 1994)(Figure 10). As shown in Figure 9, the averages of the angles range from 36.18° to 61.34°, meaning that most of these skin tone colours are in the middle of the red-yellow quadrant. As we can see, there are also some colours that are just

within the red-blue quadrant as observed by the large angles around 358 and 359 degrees, Although they are very close to the red 0°/360° mark. These results are to be expected of these colours, as skin tones are generally warm-toned and some may fall slightly bluish in their undertones.

Analysis

Before we can discuss how to reproduce skin tones, we need to have a clear definition of what they are and how they act. As we can see from the images that were taken from ColorThink Pro, it is clear that all of the skin tones fall within the same area of the graph. The vast majority of the colours are within the GRACoL colour gamut and there are only a few dark colours that were outside of the gamut, which can be seen in Figure 6 and Figure 8.

Skin tones generally have warm (red-yellow) undertones, as shown in the data. And when we look at how those colours are reproduced, generally magenta and yellow inks are where most of the colour comes from. If these inks are not printing correctly, the skin tones will likely be effected the most. Additionally, if there is excess ink while printing in any of the colours, the high saturation could be too much for the skin tones as the colour balance in them are more neutral and not usually vibrant or over-saturated (Ashe, 2014)(Mahajan, 2019). So, trying to maintain the perfect balance of making the skin look alive, but not oversaturated or unnatural, and also not too undersaturated and lifeless, it can be a hard balance to find.

Discussion

The results do fall in line with the previous research that was done, only with a few exceptions. As we could see in figures 6 and 8, there were some colours that were out of the GRACoL colour gamut and would have not been able to be printed. Although, all of these aforementioned colours were very dark colours that were likely too complex to be able to be printed, which would mean that the shadows or dark areas of the test images could end up printing out with less depth in the colour, and ultimately might not be very noticeable on a printed item.

Although the analysis and results went well, there are still some limitations that came with this research. Some limitations of the findings would include the fact that this

study was just limited to using ColorThink Pro, which is a very powerful tool to use, but perhaps different results may have occurred if a different program was used or if the study could have included using an actual offset lithographic press to print samples rather than having to compare it to the colour gamut digitally.

However, the implications of this experiment did line up to the discussion that was started in the literature review, where the theory of skin tones being perfectly able to be printed was affirmed. This also concluded that all skin tones regardless of race fall into a similar area of the colour spectrum, and therefore can be influenced in similar ways, but colour profiling still needs to be referencing a diverse range of skin tones in order to get all the differences in tone and chroma to be accurately replicated.

Conclusion

Ultimately, the best reason why skin tones are considered difficult to print is because we have a lower tolerance for when they look correct. There are also a number of colour management errors that could go wrong along the way that particularly affect the look of skin tones the most due to their neutral colour. Whenever there may be a slight flaw in the ink management on the press, it can cause drastic changes in the results of how the skin tones come out. Once these prints come out, we immediately notice the imprecise colour more so than most other images since we spend more time in our lives looking at people or images of people than we do anything else.

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Appendix

There is too much raw data to be placed in to this document, so please refer to these Google drive links where you can find the spreadsheets of the colour data that was acquired from ColorThink Pro.

Here is a link to the folder with all the data files

Here is a link to the Kodak data
Here is a link to the Fuji data
Here is a link to the AGFA data
Here is a link to the ISO300 data
Here is a link to the GMG image of the Caucasian Woman data
Here is a link to the GMG image of the African-American man data
Here is a link to the GMG image of the Southeast Asian Woman data