Color Analysis and Microfade Testing of the 1918 Curtiss Jenny U.S. Airmail Stamp

Presented by: Thomas Lam

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Fifth International Symposium on Analytical Methods in Philately
The Institute of Analytical Philately

October 17th, 2023

Smithsonian
National Postal Museum

Smithsonian
Museum Conservation Institute

Smithsonian National Postal Museum (NPM)
Washington, DC

Smithsonian Museum Conservation Institute (MCI)
Suitland, MD

Gems exhibit in the William H. Gross Stamp Gallery

The Inverted Jenny

NPM 0.217665.1

Stamp: 2 cm by 2.5 cm

In 1918, the Bureau of Engraving and Printing (BEP) issued the first bi-colored stamp for airmail, a special delivery postage stamp known as the Curtiss Jenny.

It is most famous for the printing error resulting in the Inverted Jenny, arguably the most iconic of American stamps. Its popularity and rarity make its protection particularly important.

Although we know that exposure to light can pose a risk to papers and inks, much remains unknown.

Smithsonian National Postal Museum (NPM) provided us an opportunity to do research on a non-inverted Jenny and access to the 1918 proofs within the NPM collection.

Outline

1. Stamps and Proofs Studied
   Color Analysis by Foster and Freeman Video Spectral Comparator (VSC8000/HS)

2. Color Difference: ΔE2000

3. Color Simulation

4. Color Analysis of the Paper, Blue, and Red

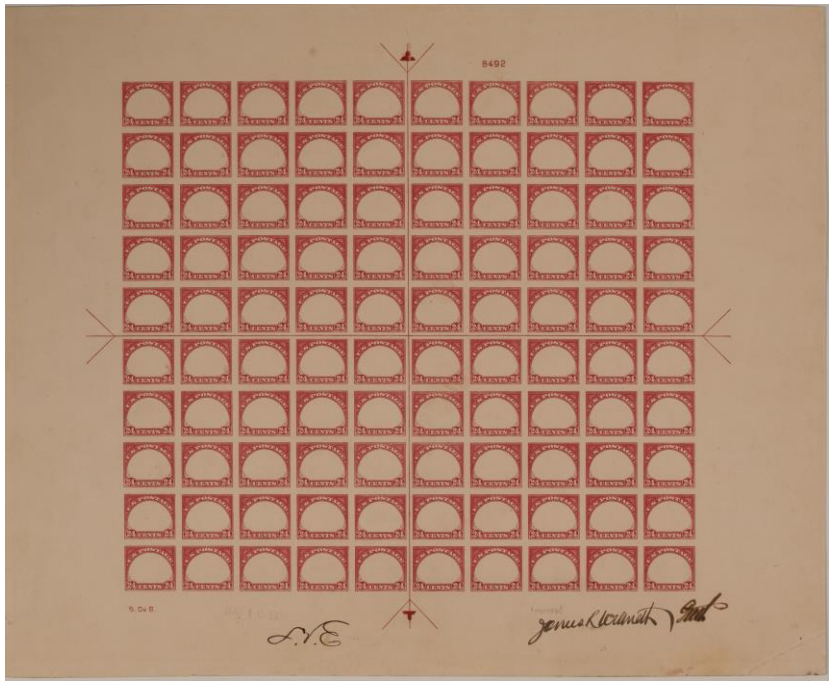
5. Microfade Testing (MFT) and MFT Interpretation

6. Light Exposure Calculation

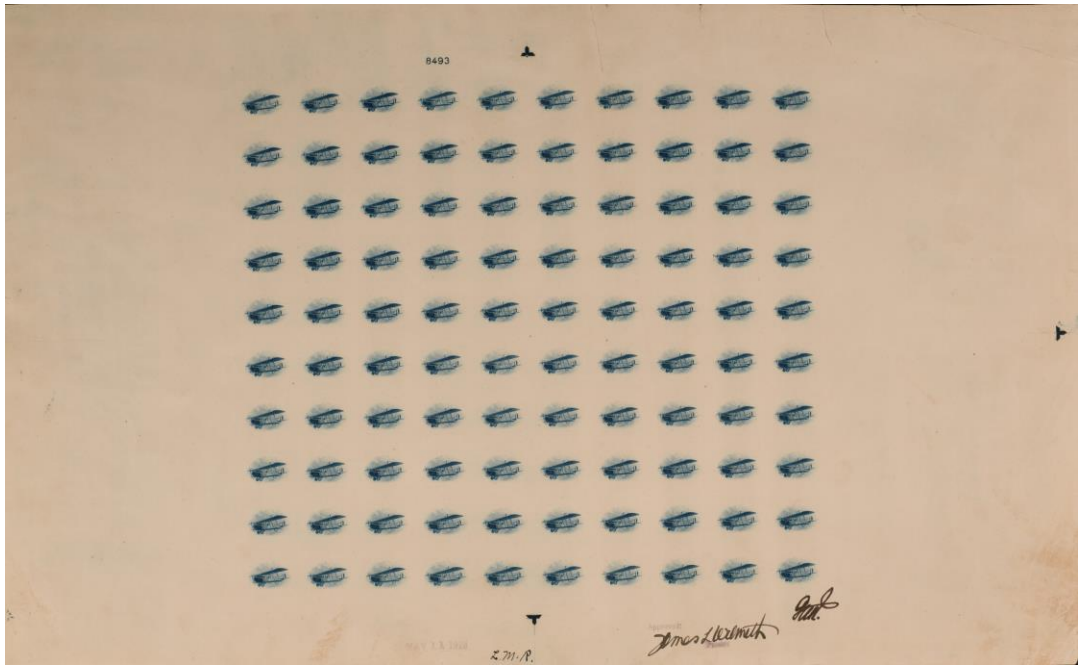
7. Conclusion and Future Work

1918 Jenny Stamps in this Study

Curtiss Jenny Plate Proofs

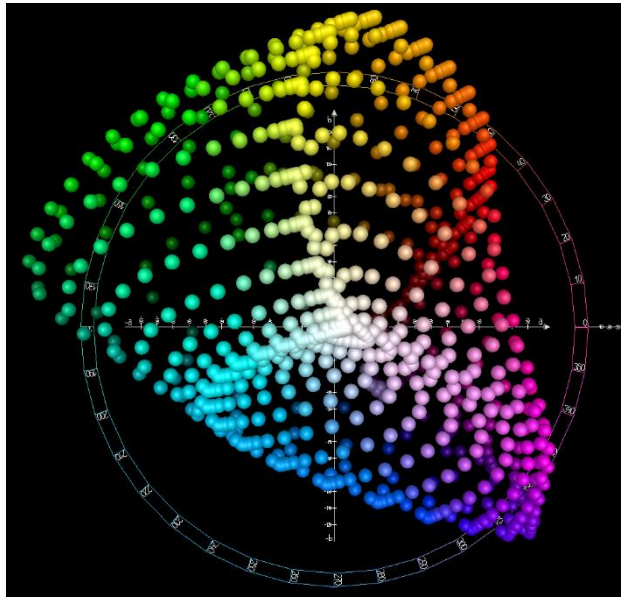


0.242263.15824



0.242263.15825

Color Difference: ΔE_{00}



$$\Delta E^*_{ab} = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

$$\Delta E^*_{00} = \frac{\Delta L'}{k_L S_L} \left(\frac{\Delta C'}{k_C S_C}\right) \left(\frac{\Delta H'}{k_H S_H}\right) \frac{\Delta C'}{k_C S_C} \frac{\Delta H'}{k_H S_H}$$

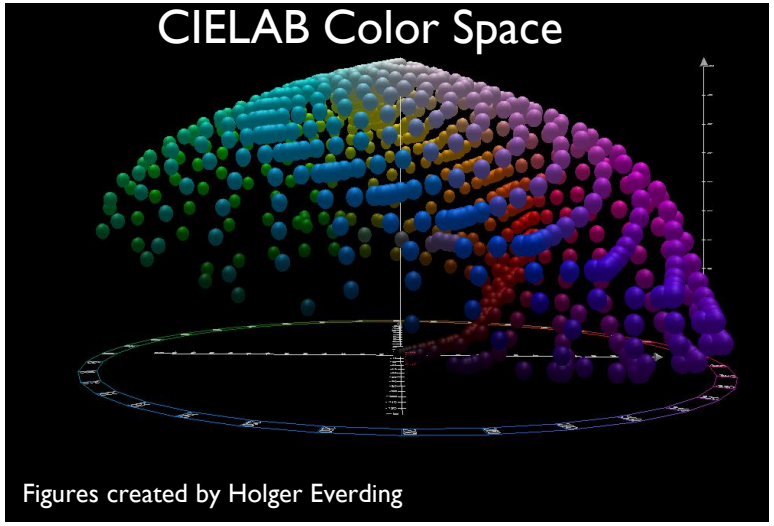
Lightness Correction

Chroma Correction

Hue Correction

Hue Dependent Rotation Function

Neutral Correction



*Excel calculation sheet by Olivia Kuzio can be available upon request (please email LamT@SI.edu). We just ask that should you use the excel sheet please provide a citation to credit her:

Kuzio, O. (2018) Excel Sheet to Calculate DE2000 from CIE L*, a*, b*.

postalmuseum.si.edu/revealing-the-rainbow-an-introduction-to-the-science-of-color

Revealing the Rainbow: An Introduction to the Science of Color

Thursday, October 12th, 4:00 PM ET. Online on Zoom.

Register here

Please join us as **Olivia R. Kuzio**, Professional Fellow at the Getty Conservation Institute, introduces the science of color.

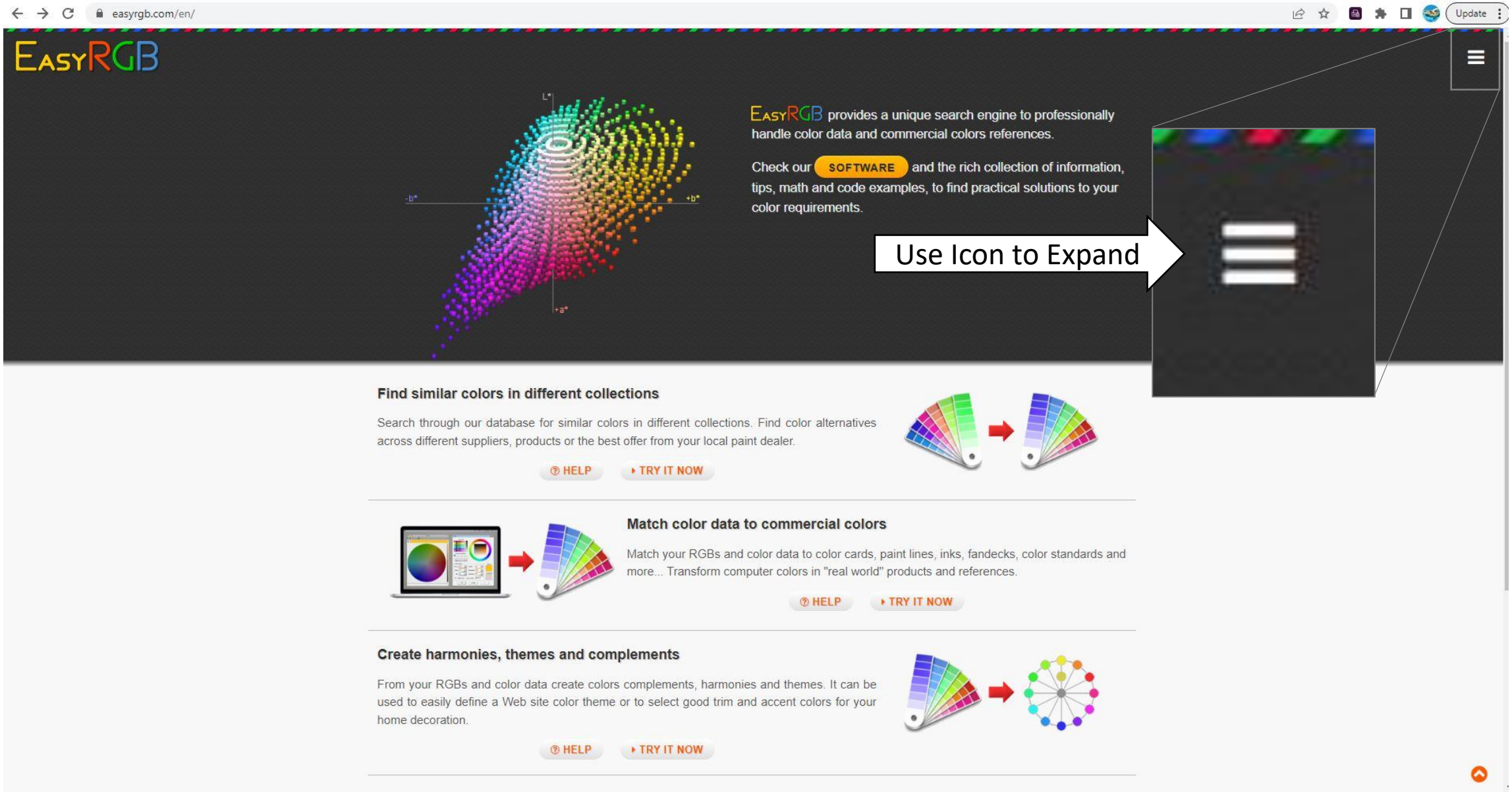
Color is what we see…but it is also more than meets the eye. Color is an effect on the visual system and in the brain. Color is physically imparted on materials by colorants. Color is also a specific kind of light. Color is a manifestation, a response, and a perception. Color is simultaneously simple ("Bananas are yellow.") and complicated ("This paint looks different on my wall than it did at Home Depot."). Ultimately, color is central to the character and essence of the world we navigate every day.

In this world, where color can mean many things, this talk will consider how color is created, and introduce the ways in which this web of phenomena affects the description, categorization, measurement, and comparison of color.

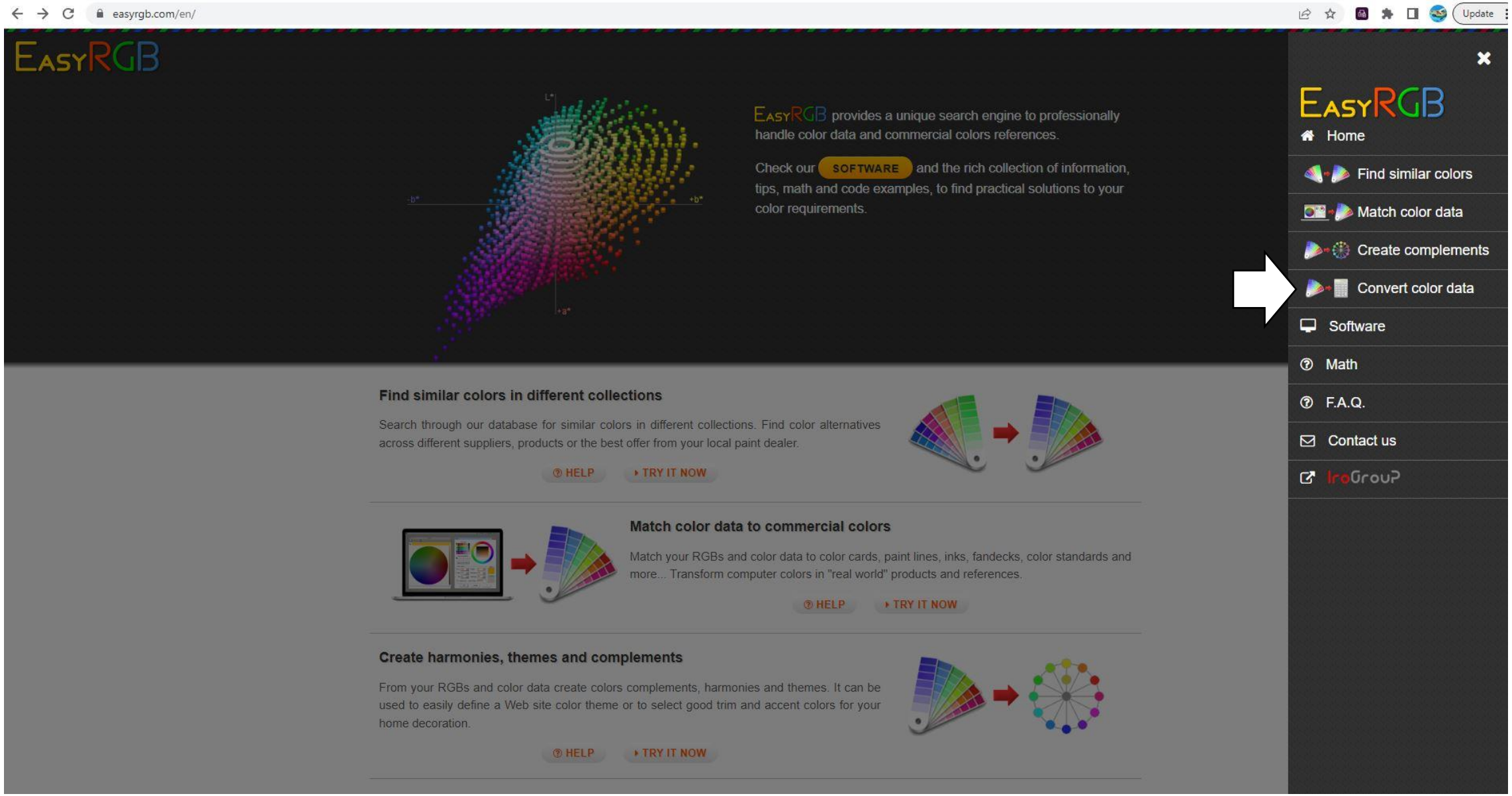
About Olivia R. Kuzio

Olivia Kuzio's talk was recorded and should be uploaded to NPM YouTube channel by next calendar year

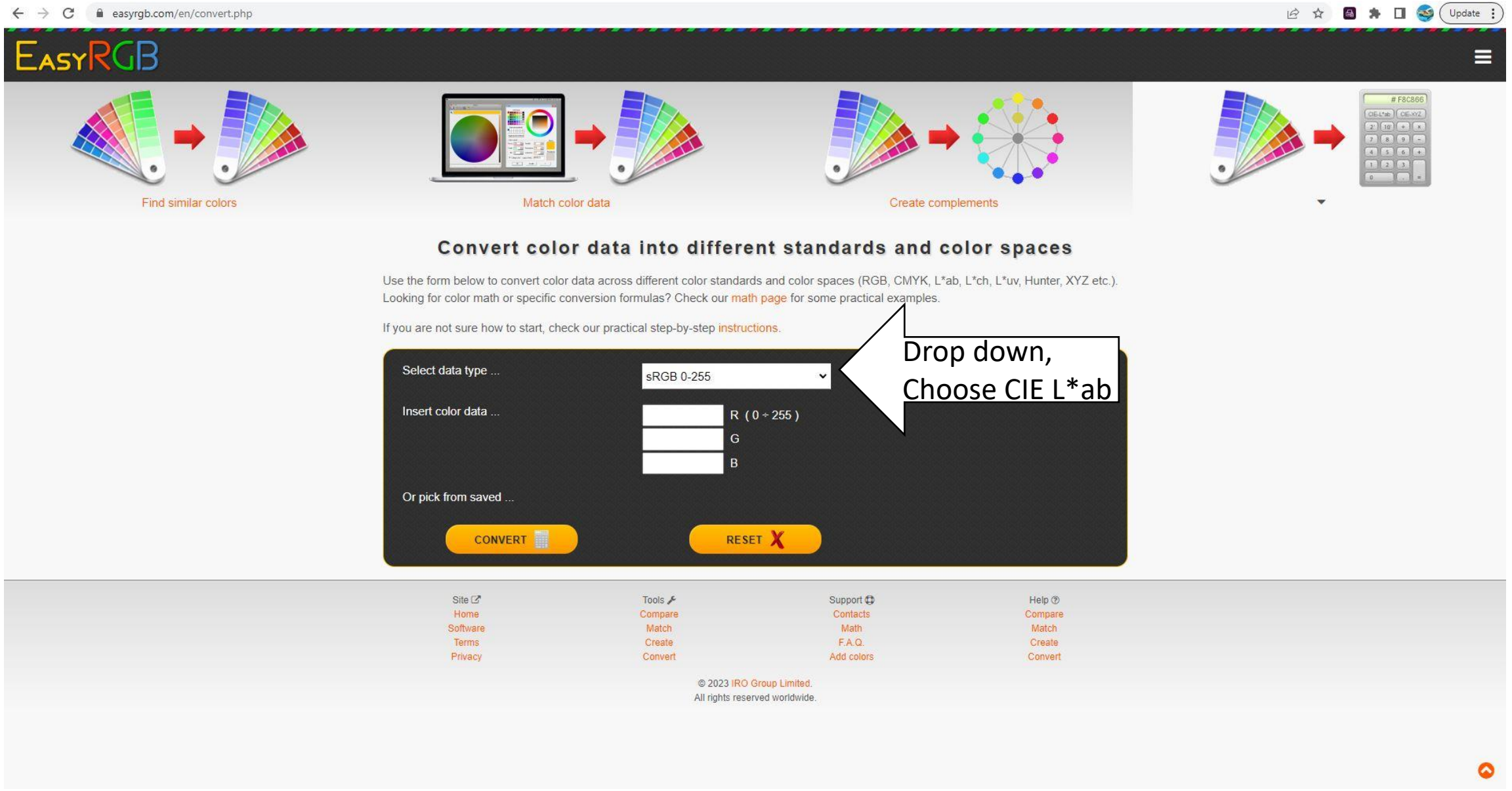
Color Simulation using easyrgb.com



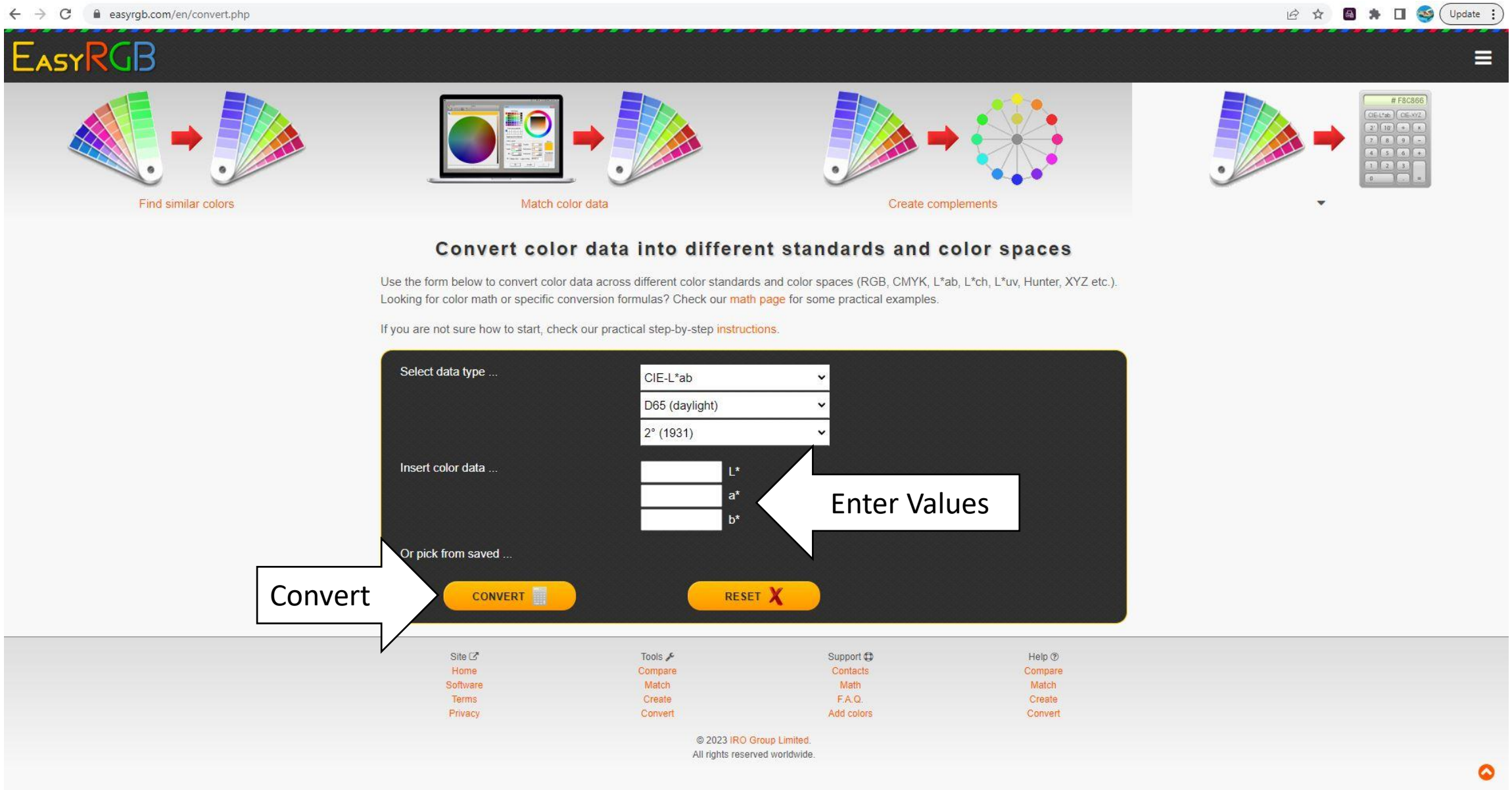
Color Simulation using easyrgb.com



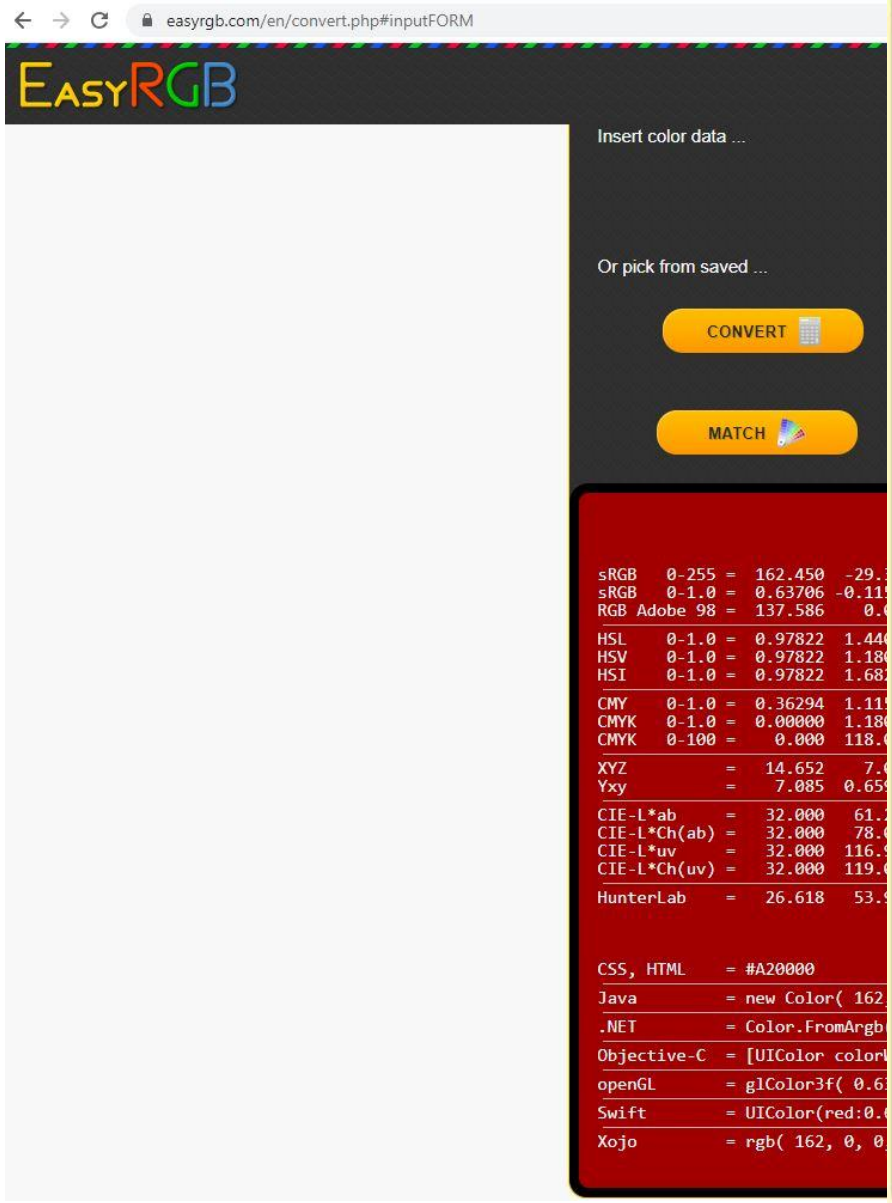
Color Simulation using easyrgb.com

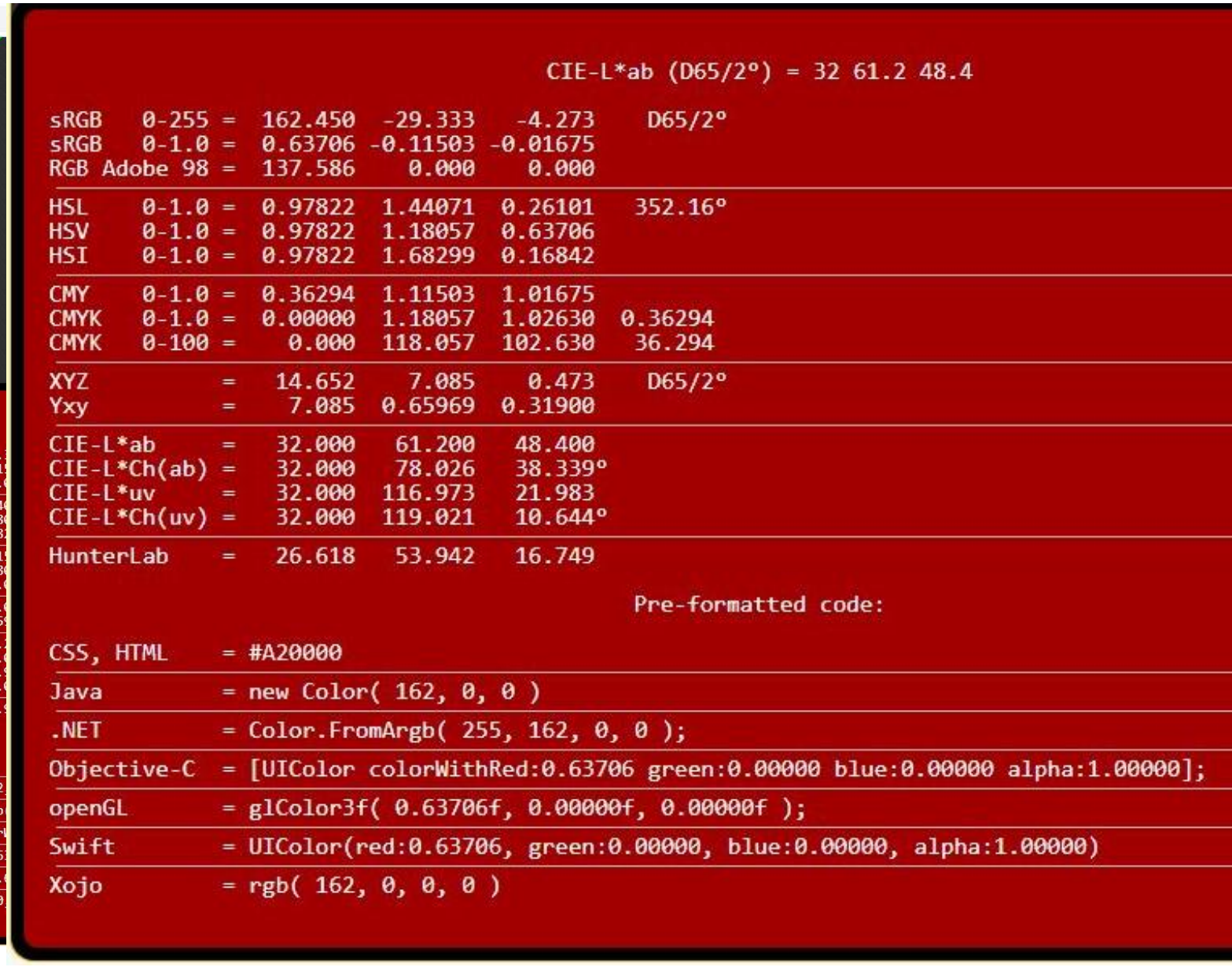


Color Simulation using easyrgb.com



Color Simulation using easyrgb.com





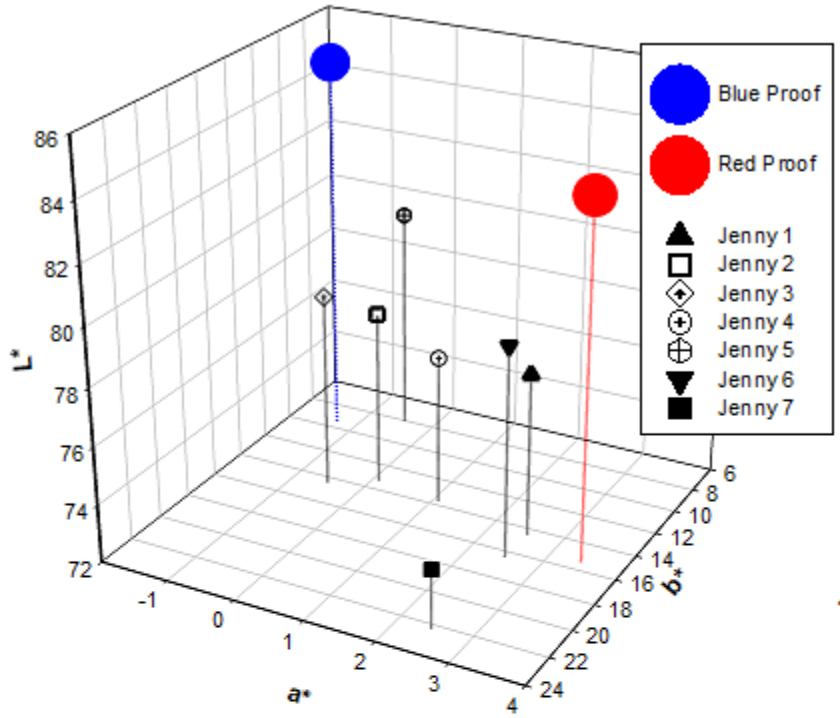
CIE-L*ab (D65/2°) = 32 61.2 48.4

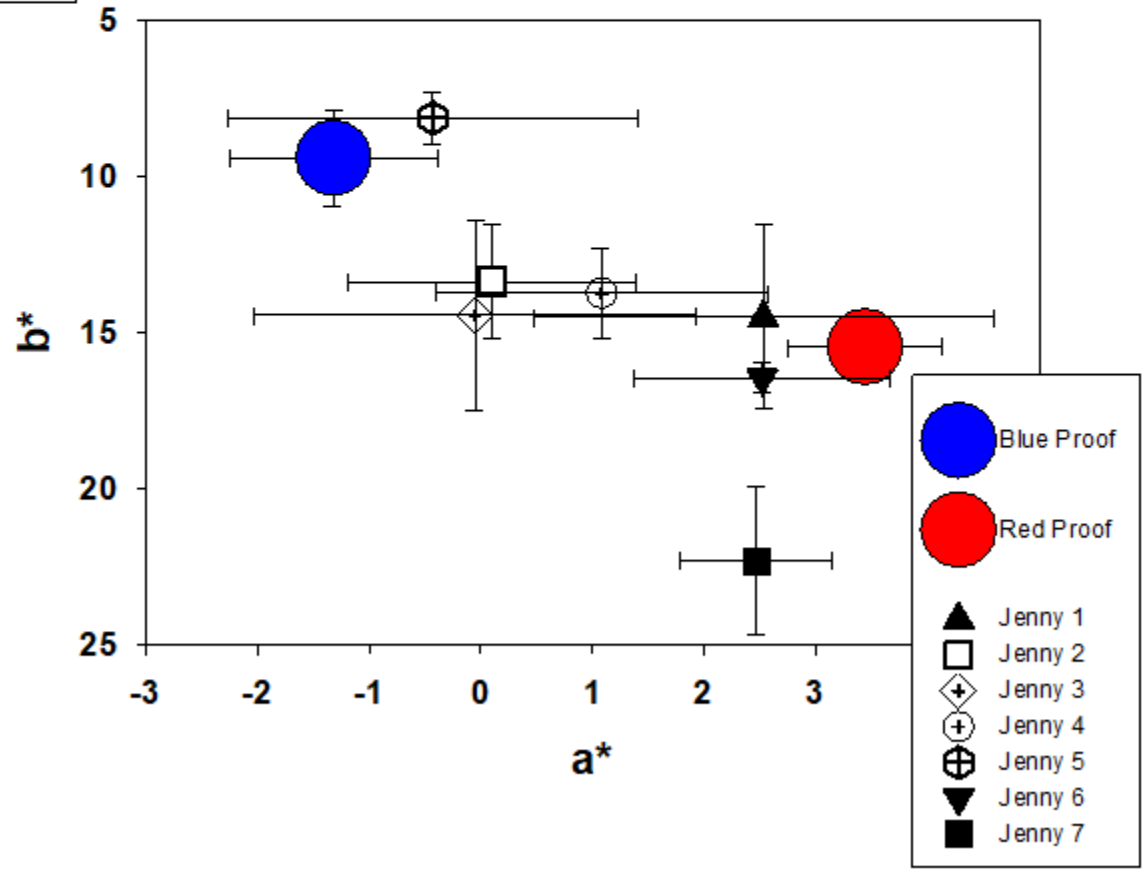
sRGB	0-255 =	162.450	-29.333	-4.273	D65/2°
sRGB	0-1.0 =	0.63706	-0.11503	-0.01675	
RGB Adobe 98	=	137.586	0.000	0.000	
HSL	0-1.0 =	0.97822	1.44071	0.26101	352.16°
HSV	0-1.0 =	0.97822	1.18057	0.63706	
HSI	0-1.0 =	0.97822	1.68299	0.16842	
CMY	0-1.0 =	0.36294	1.11503	1.01675	
CMYK	0-1.0 =	0.00000	1.18057	1.02630	0.36294
CMYK	0-100 =	0.000	118.057	102.630	36.294
XYZ	=	14.652	7.085	0.473	D65/2°
Yxy	=	7.085	0.65969	0.31900	
CIE-L*ab	=	32.000	61.200	48.400	
CIE-L*Ch(ab)	=	32.000	78.026	38.339°	
CIE-L*uv	=	32.000	116.973	21.983	
CIE-L*Ch(uv)	=	32.000	119.021	10.644°	
HunterLab	=	26.618	53.942	16.749	

Pre-formatted code:

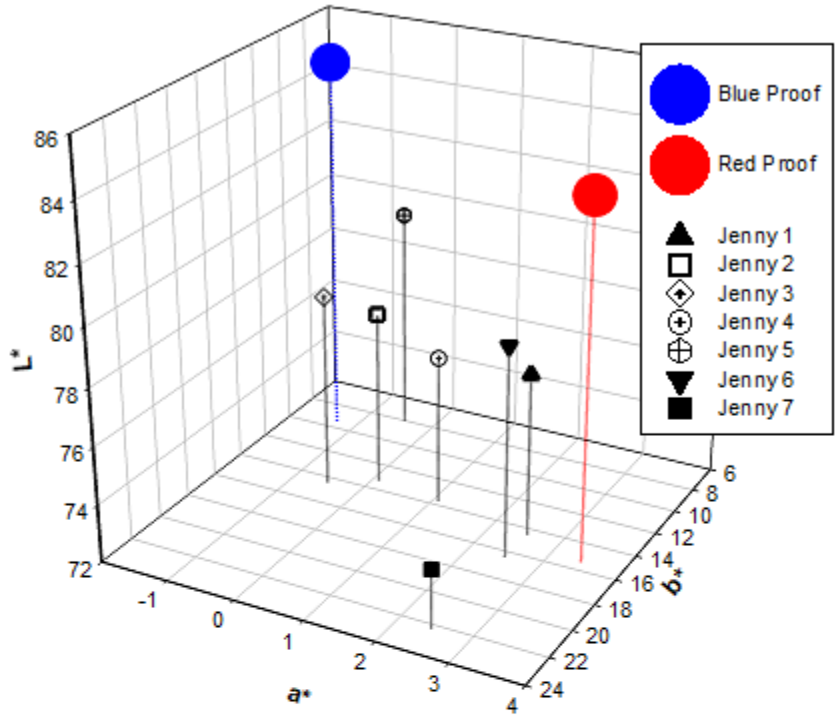
CSS, HTML	= #A20000
Java	= new Color(162, 0, 0)
.NET	= Color.FromArgb(255, 162, 0, 0);
Objective-C	= [UIColor colorWithRed:0.63706 green:0.00000 blue:0.00000 alpha:1.00000];
openGL	= glColor3f(0.63706f, 0.00000f, 0.00000f);
Swift	= UIColor(red:0.63706, green:0.00000, blue:0.00000, alpha:1.00000)
Xojo	= rgb(162, 0, 0, 0)

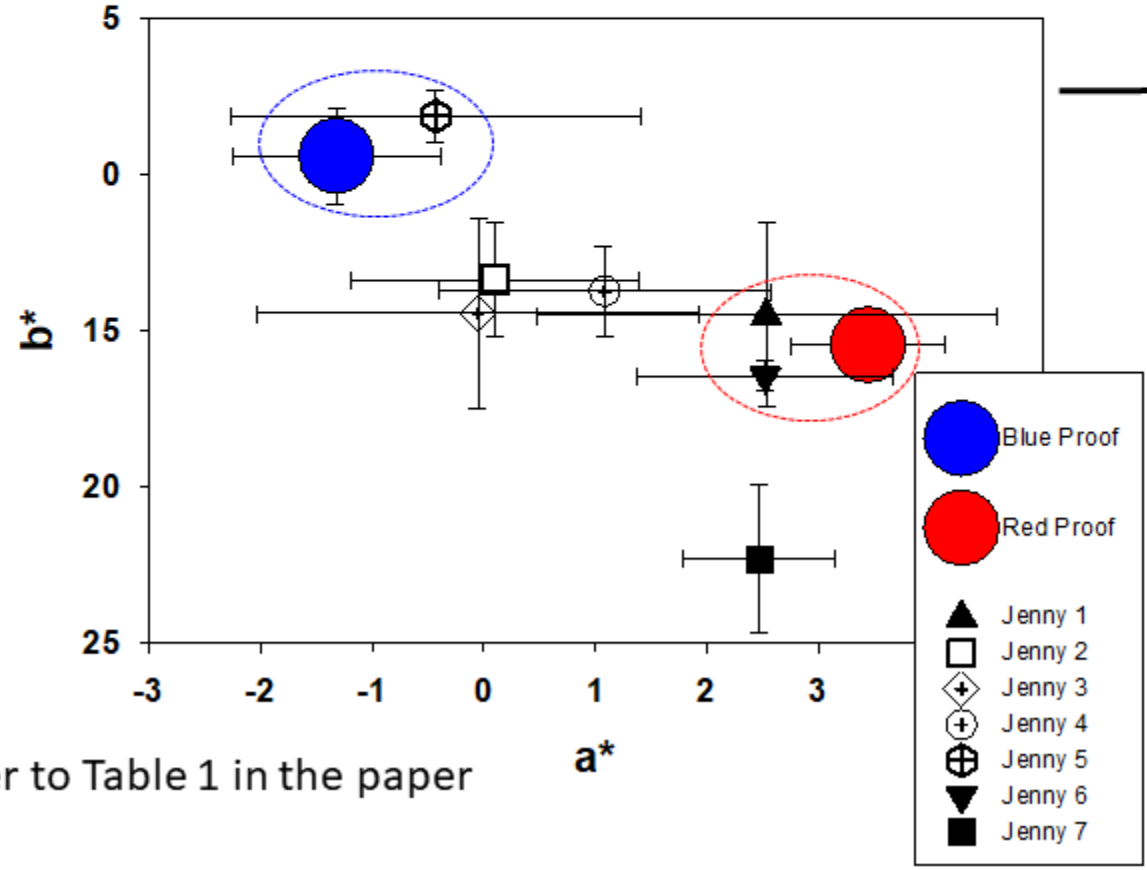
Analysis of the Paper





Analysis of the Paper

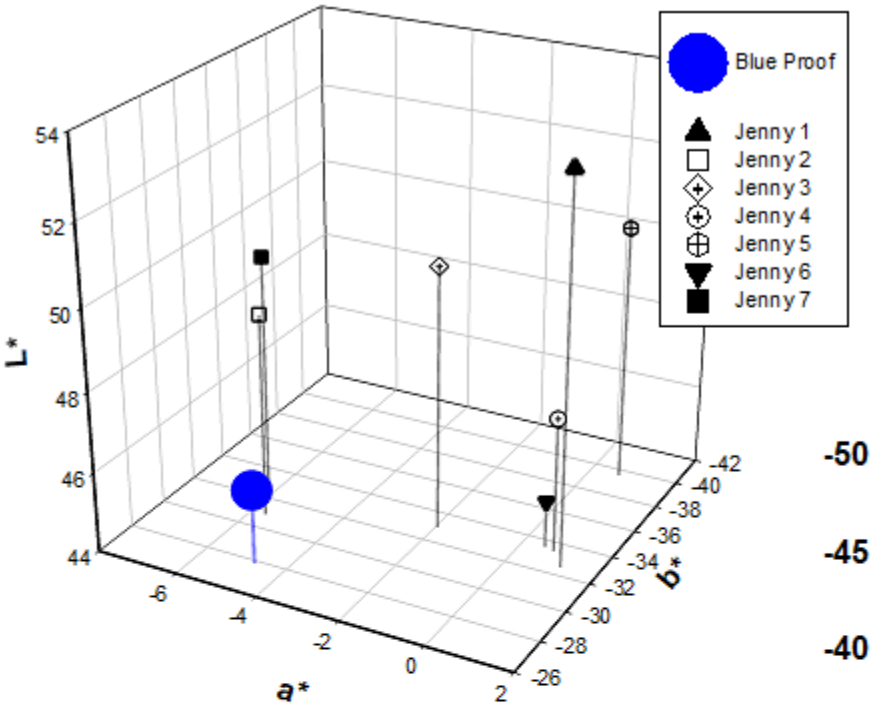


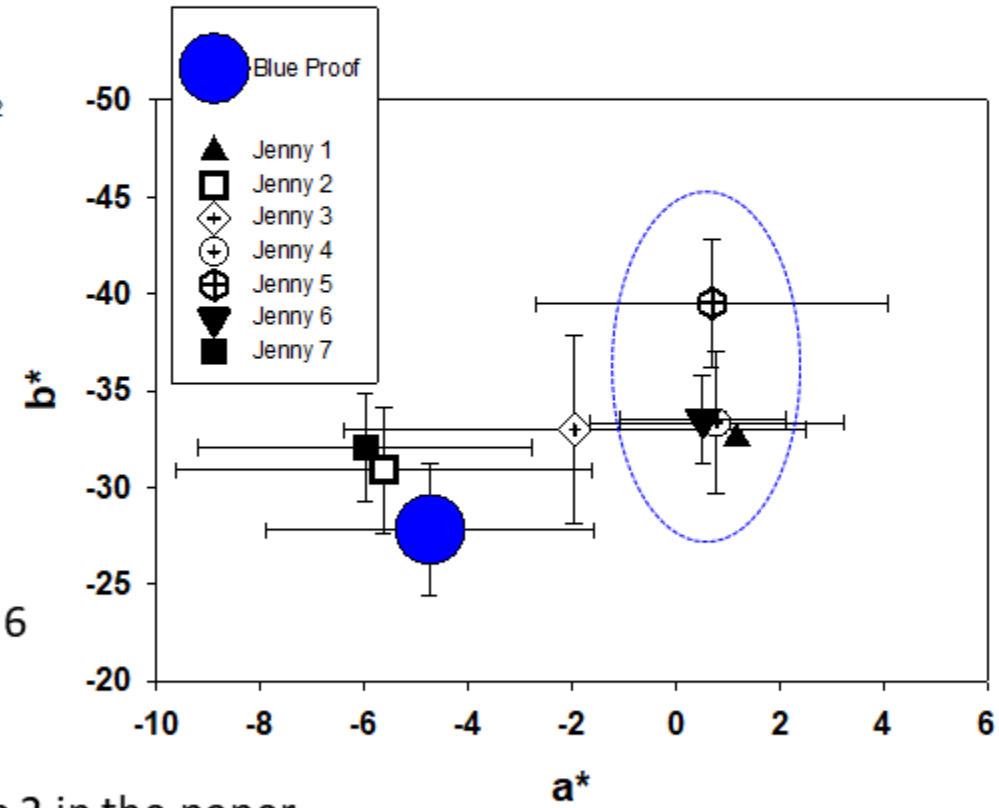


	Simulated Color
Blue Proof	
Red Proof	
Jenny 1	
Jenny 2	
Jenny 3	
Jenny 4	
Jenny 5	
Jenny 6	
Jenny 7	

For further L*, a*, and b* details refer to Table 1 in the paper

Analysis of the Blue Ink





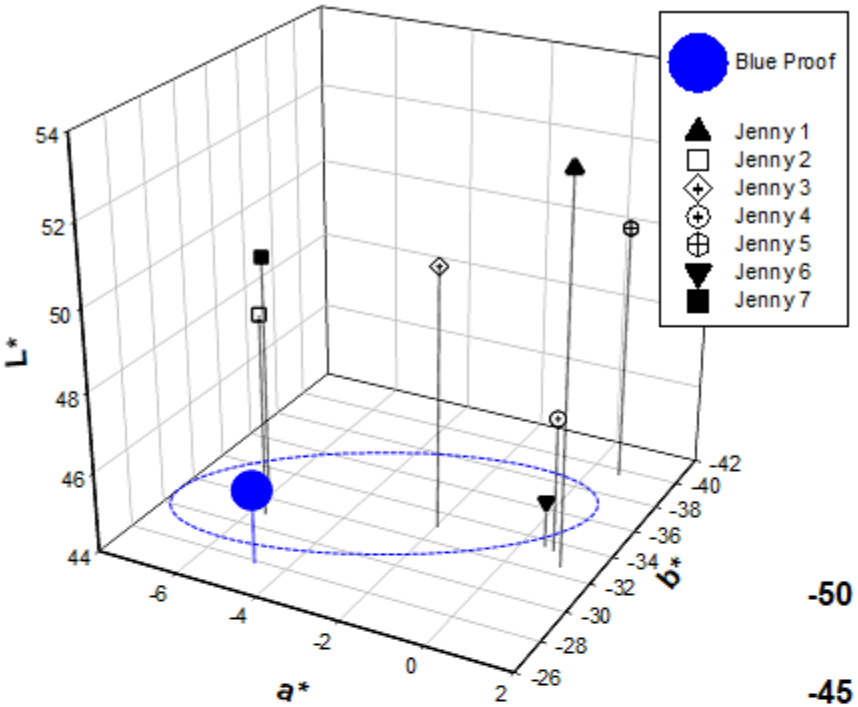
ANOVA, Holm-Sidak

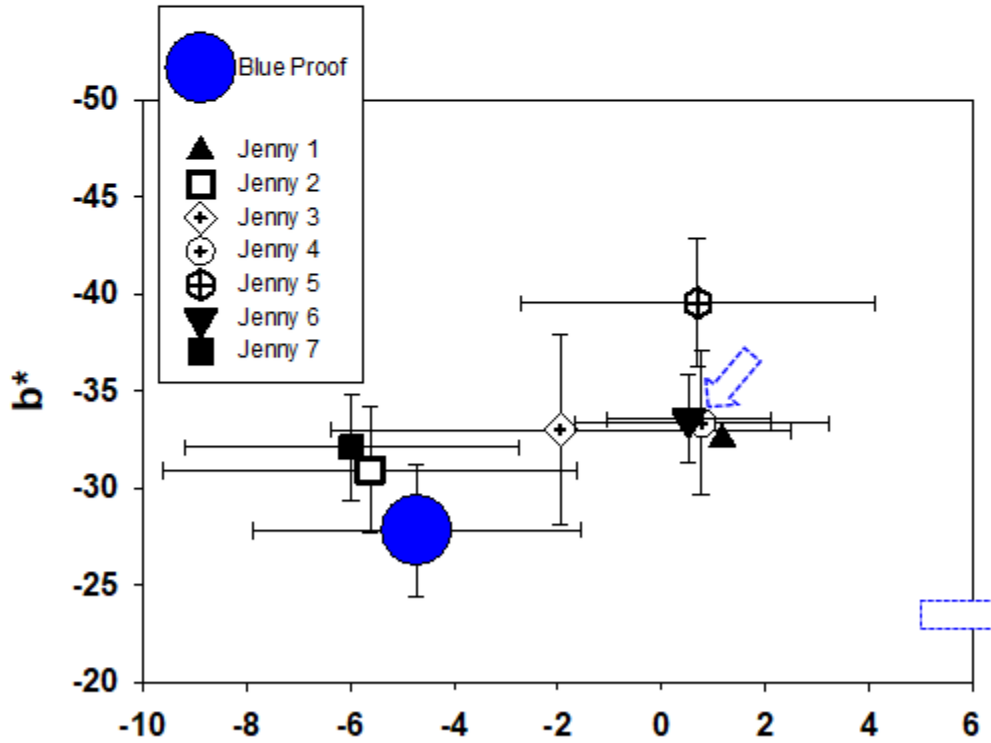
Jenny 1, Jenny 4, Jenny 5, and Jenny 6 are statistically different

For ANOVA, Holm-Sidak refer to Table 2 in the paper

For further L*, a*, b*, σ details refer to Table 1 in the paper

Analysis of the Blue

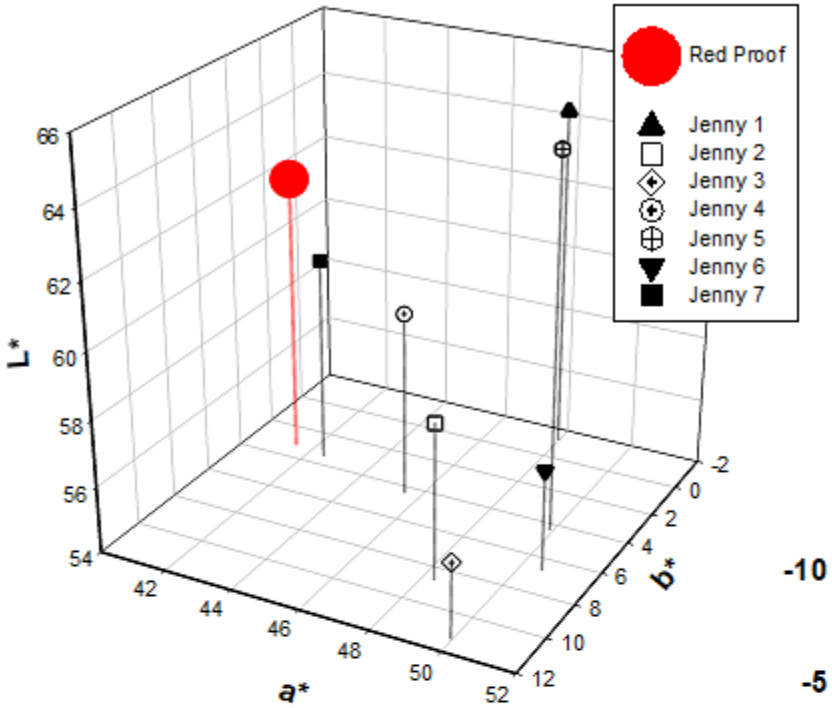


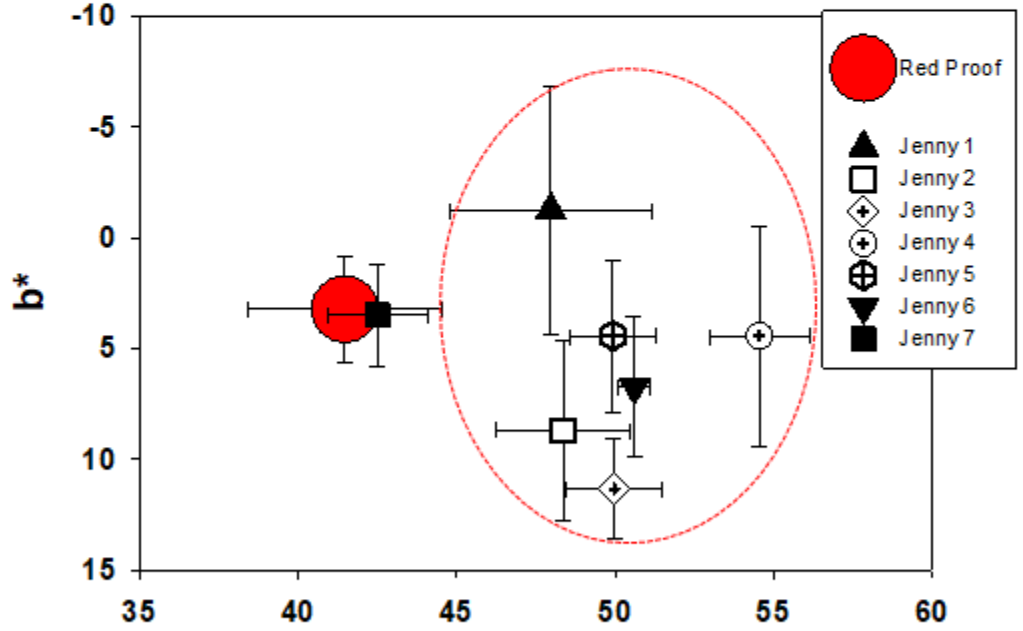


		ΔE^*_{00}	Simulated Color
Blue Proof	●	NA	
Jenny 1	▲	7.98	
Jenny 2	□	4.69	
Jenny 3	◇	5.56	
Jenny 4	⊕	4.84	
Jenny 5	⬡	5.78	
Jenny 6	▼	3.76	
Jenny 7	■	5.04	

For further L*, a*, b*, σ details refer to Table 3 in the paper

Analysis of the Red Ink





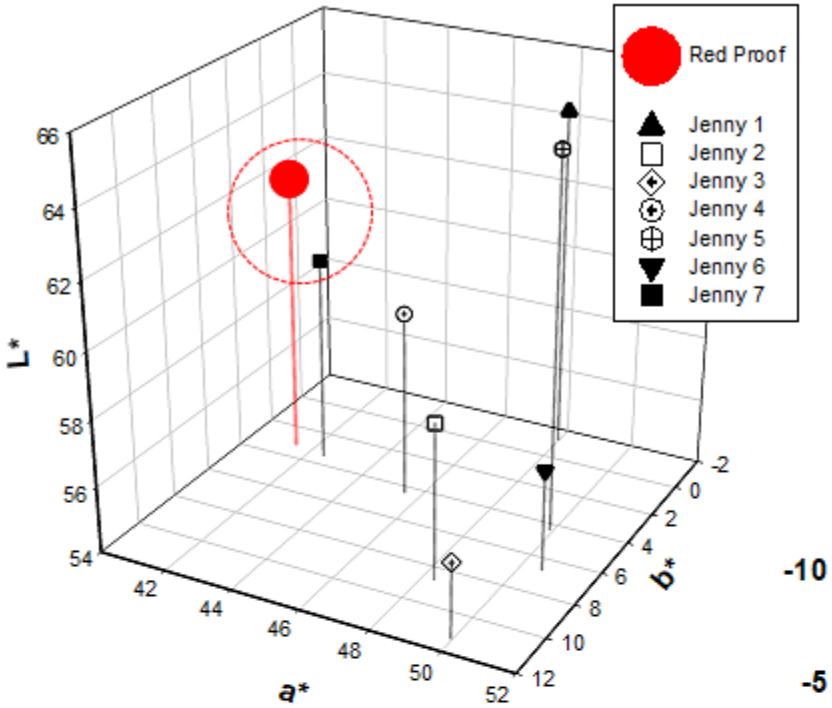
ANOVA, Holm-Sidak

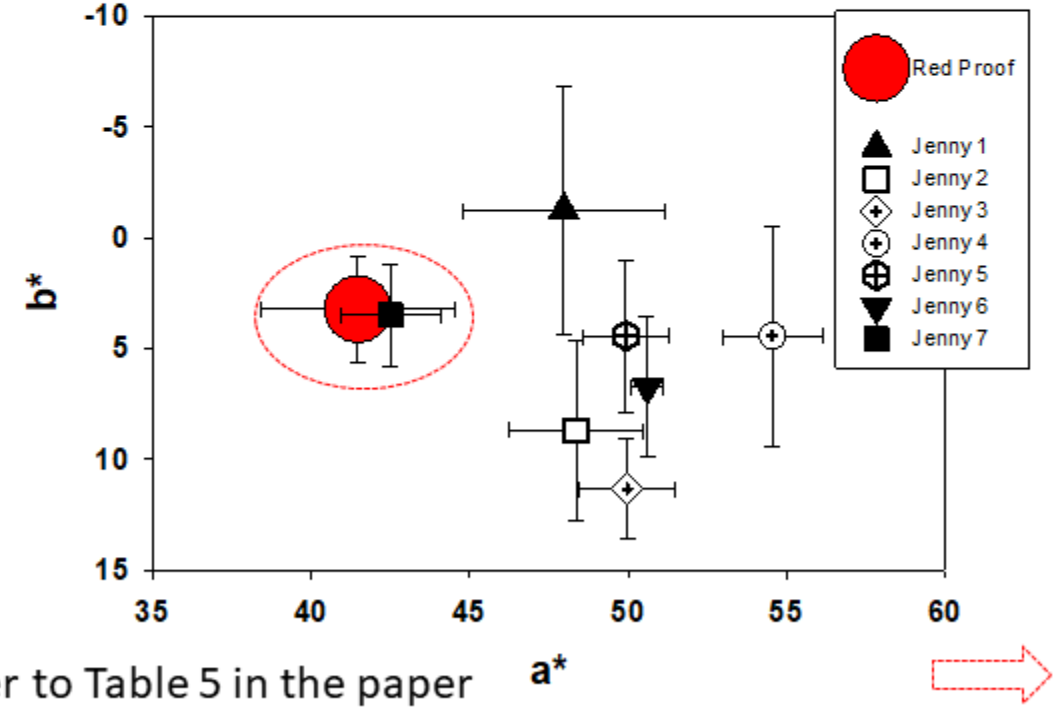
Jenny 1- 6
are statistically different

For ANOVA, Holm-Sidak refer to Table 4 in the paper

For further L*, a*, b*, σ details refer to Table 5 in the paper

Analysis of the Red

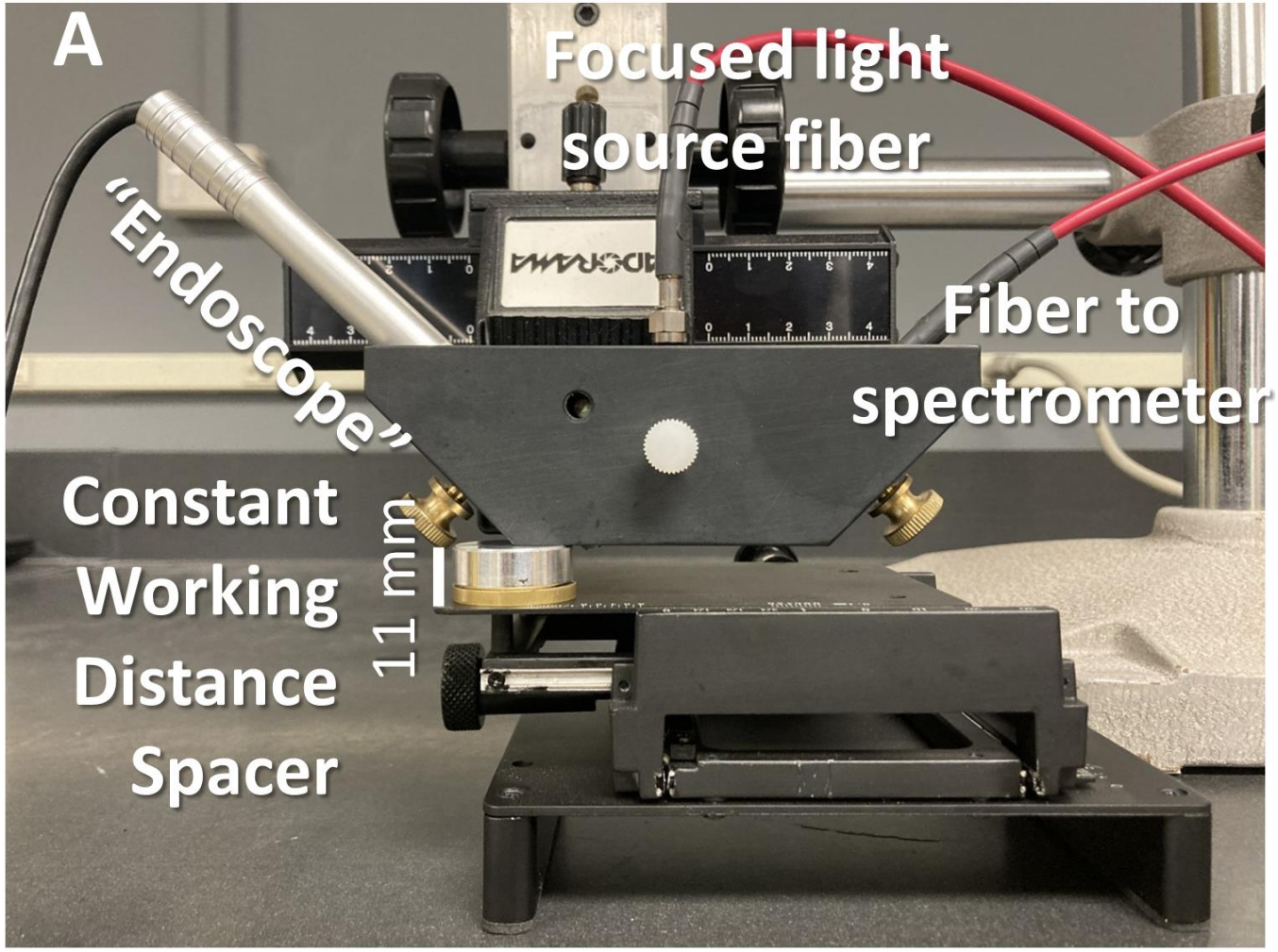


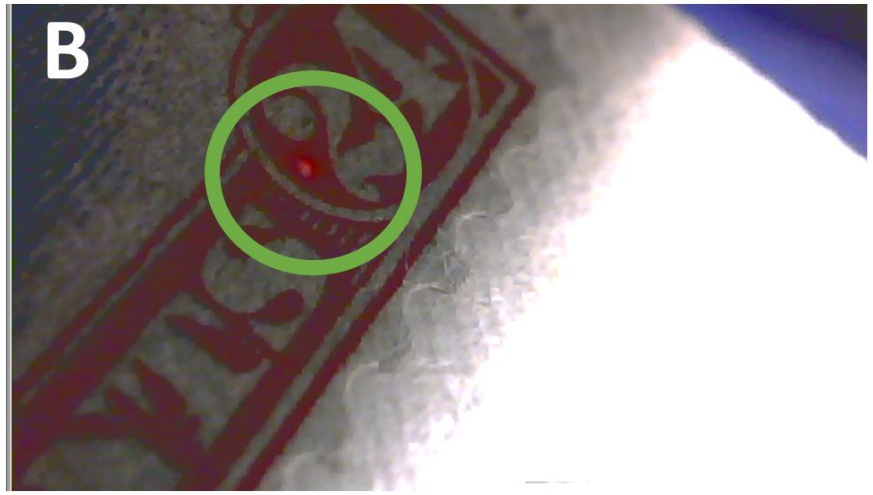


		ΔE^*_{00}	Simulated Color
Red Proof	●	NA	
Jenny 1	▲	5.49	
Jenny 2	□	5.39	
Jenny 3	◇	7.40	
Jenny 4	⊕	5.61	
Jenny 5	⊞	4.19	
Jenny 6	▼	6.03	
Jenny 7	■	3.48	

For further L*, a*, b*, σ details refer to Table 5 in the paper

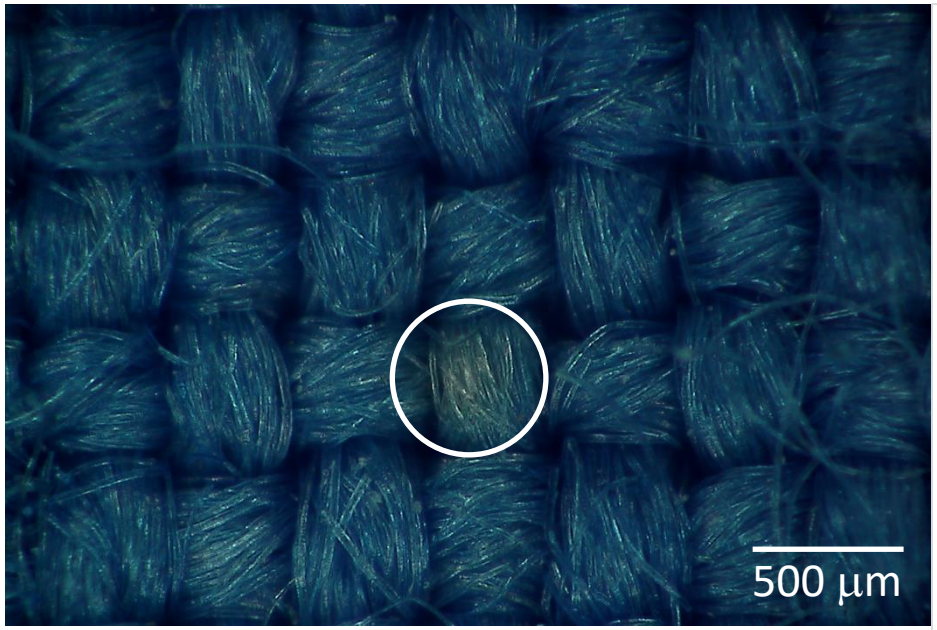
Microfade Testing (MFT)

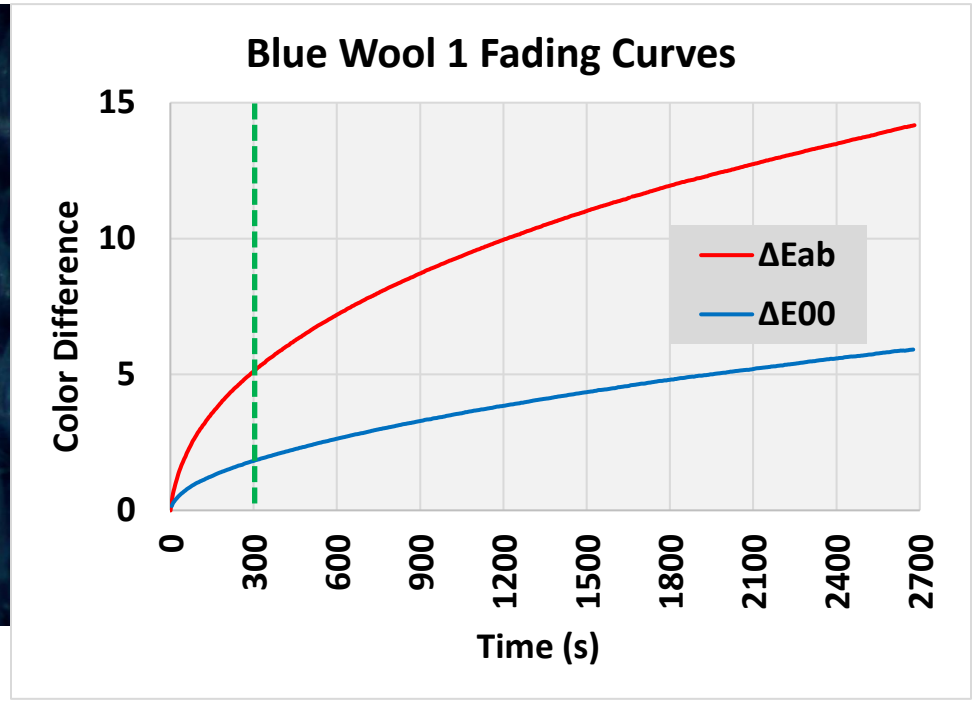




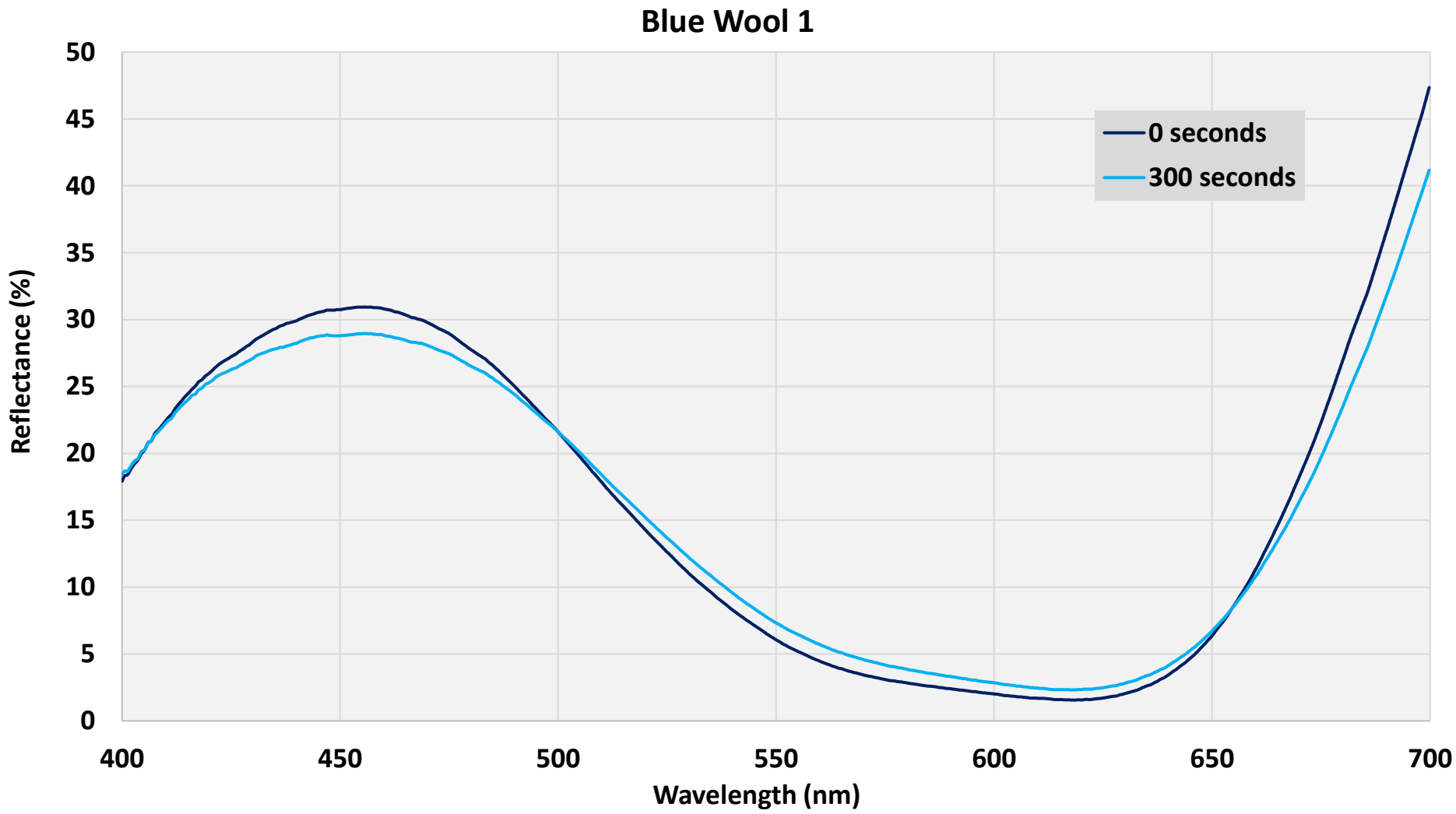
Microfade Testing (MFT)

Direct light sensitivity assessment on actual objects using a focused source to induce accelerated fading





Spectral Difference After MFT

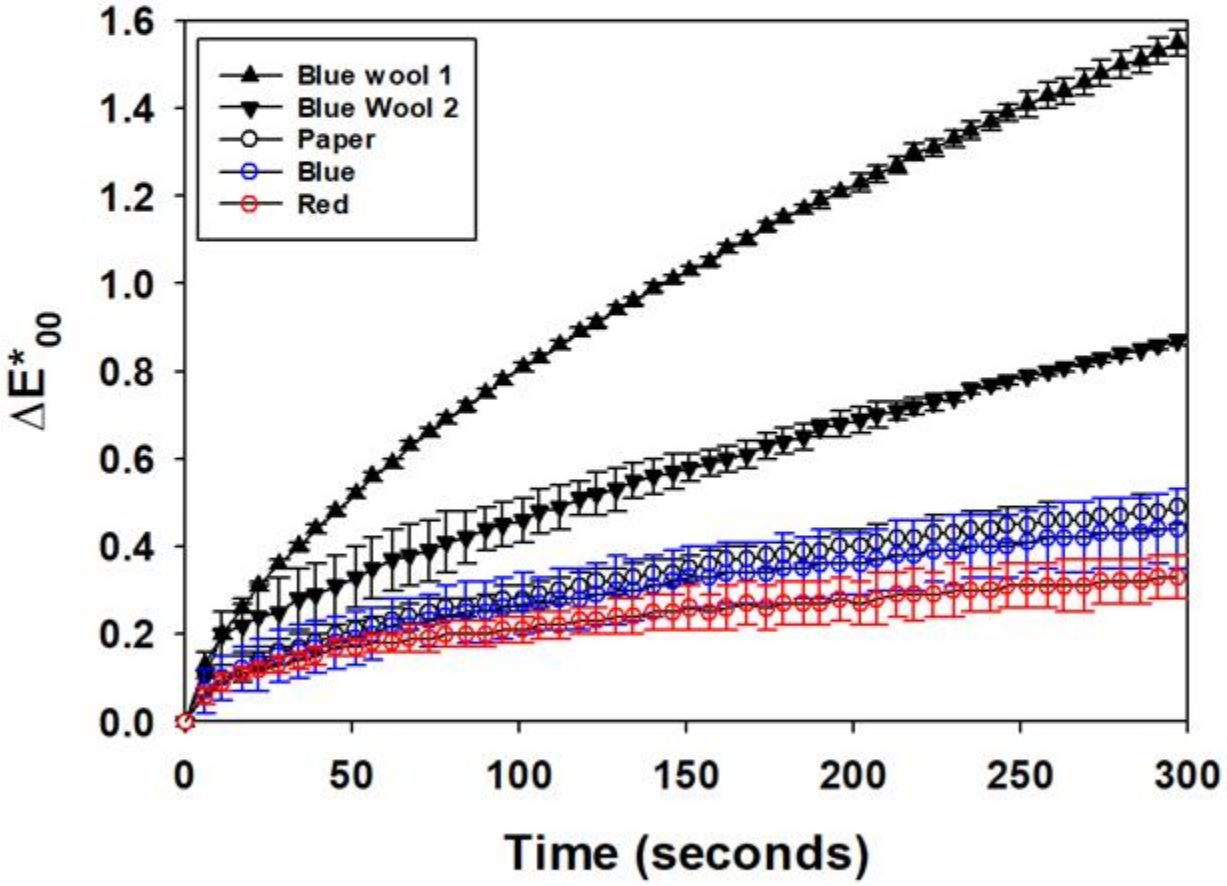


Technique Comparisons on Ceramic Color Tiles

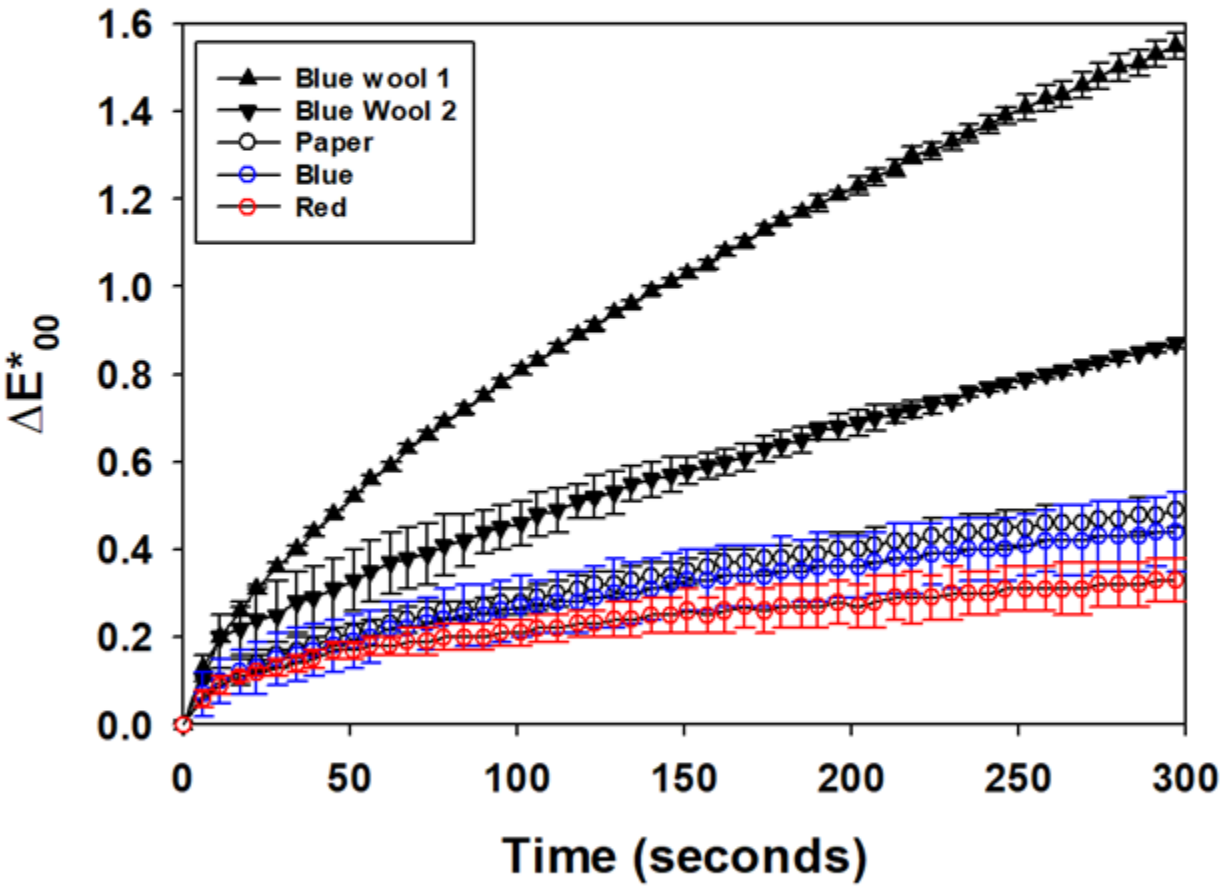
	Method	ΔE_{00}^{*}	Simulated Color	Actual Color
Red Tile	VSC avg	2.36	L*=34.03, a*=64.13, b*=48.87	L*=32.00, a*=61.20, b*=48.40
	MFT avg	2.93	L*=30.68 a*=66.99,b*= 52.89	
Green Tile	VSC avg	1.17	L*=26.75, a*=-19.17,b*= 6.75	L*=27.00, a*=-18.10, b*=7.30
	MFT avg	5.77	L*=21.97, a*=-25.63,b*= 7.88	
Blue Tile	VSC avg	1.81	L*=15.25, a*=19.88, b*= -38.95	L*=17.60, a*=19.00, b*= -39.20
	MFT avg	6.11	L*=10.56, a*=25.71, b*= -51.22	

Ceramic color tiles are from Hale Consultants
Reference color measurements traceable to
National Bureau of Standards (NBS) now
National Institute of Standards and Technology (NIST)
Normalized with white tile or white reference

MFT of Jenny 7



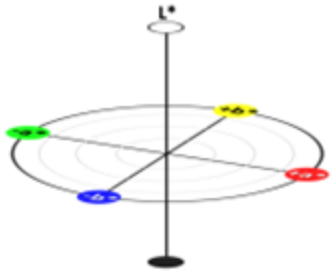
MFT of Jenny 7



	ΔE^*_{00}	Simulated Color
VSC Paper Color	NA	L*=74.03, a*=2.47, b*=22.30
MFT Paper Color	2.80	L*=71.77, a*=4.48, b*=24.11
VSC Blue Color	NA	L*=34.87, a*=-7.27, b*=-15.08
MFT Blue Color	3.65	L*=32.62, a*=-9.22, b*=-17.72
VSC Red Color	NA	L*=43.87, a*=39.77, b*=17.30
MFT Red Color	5.48	L*=47.60, a*=43.66, b*=25.5

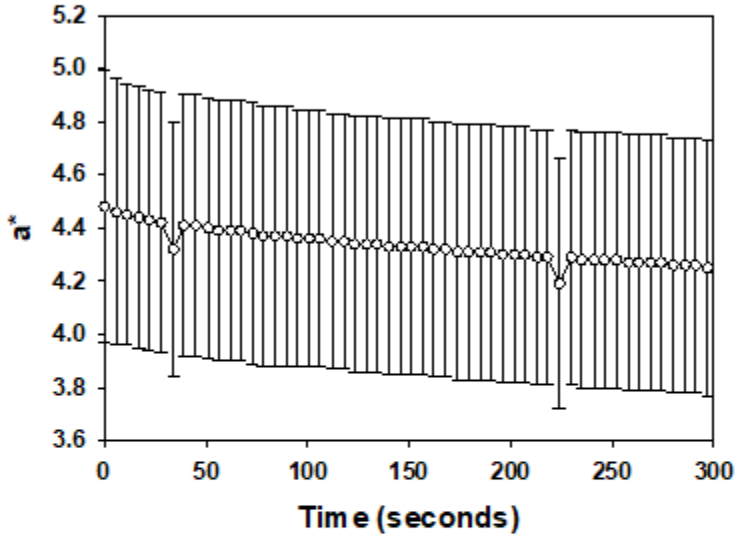
White tile was used for both VSC and MFT measurements

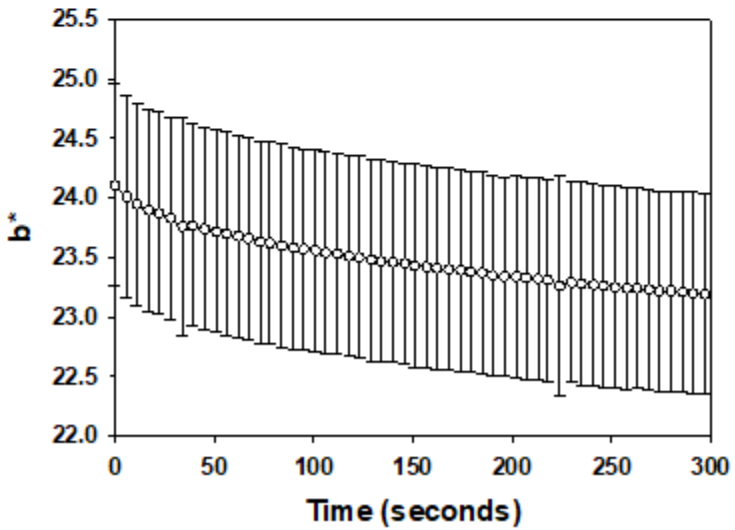
Simulated MFT color is at the starting point



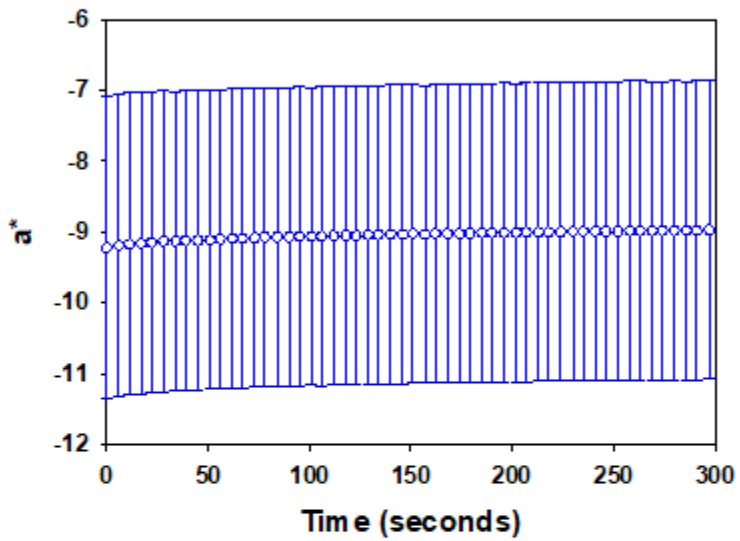
MFT of Jenny 7

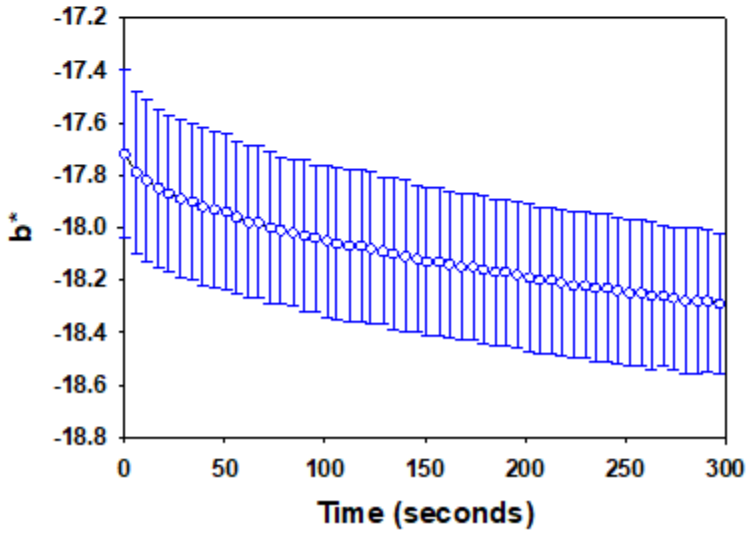
Paper

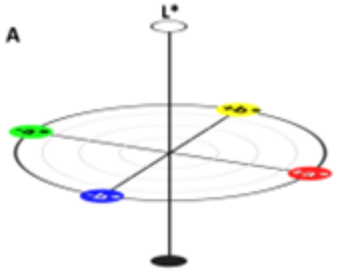




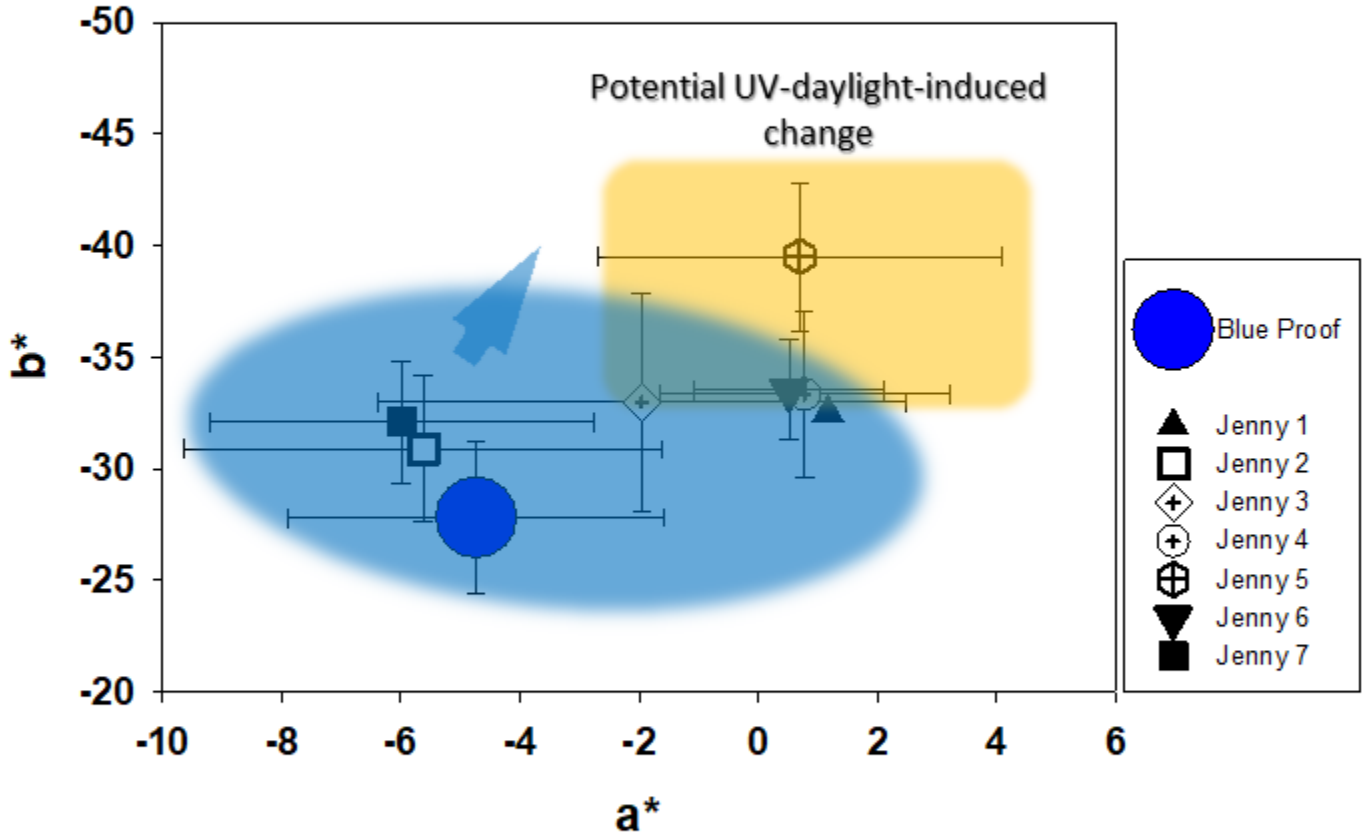
Blue

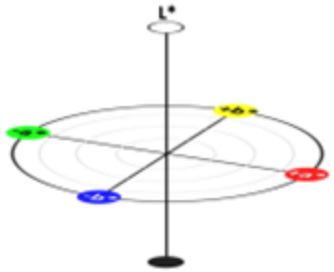






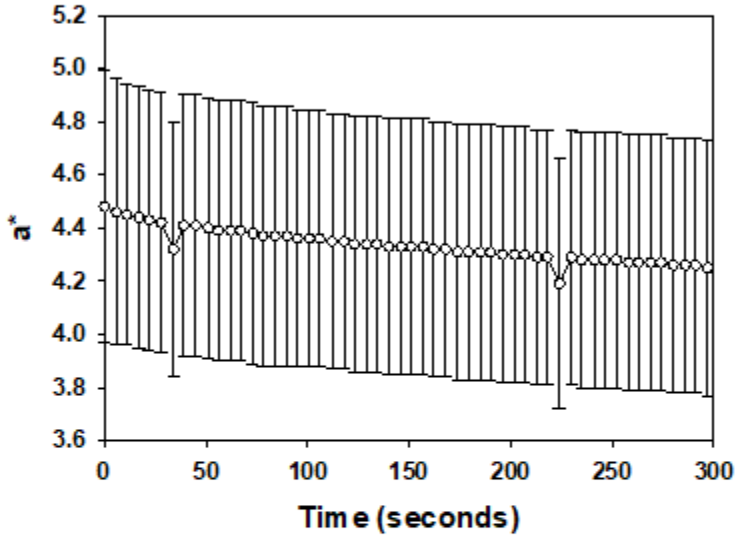
MFT Interpretation for the Blue

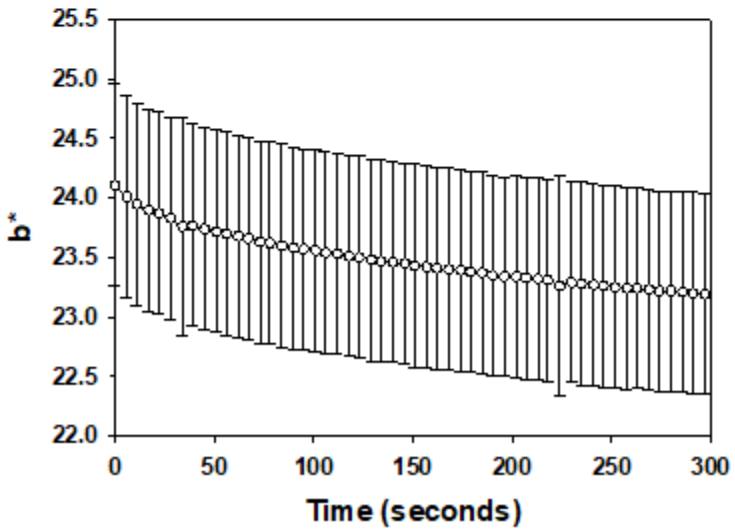




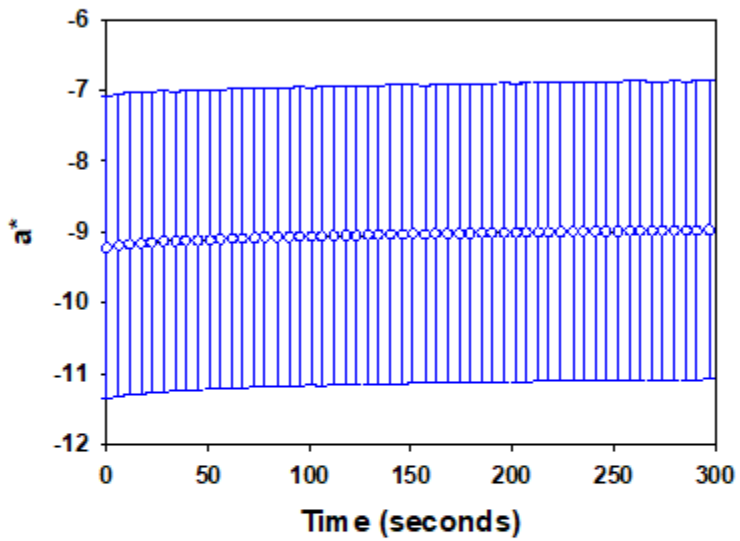
MFT of Jenny 7

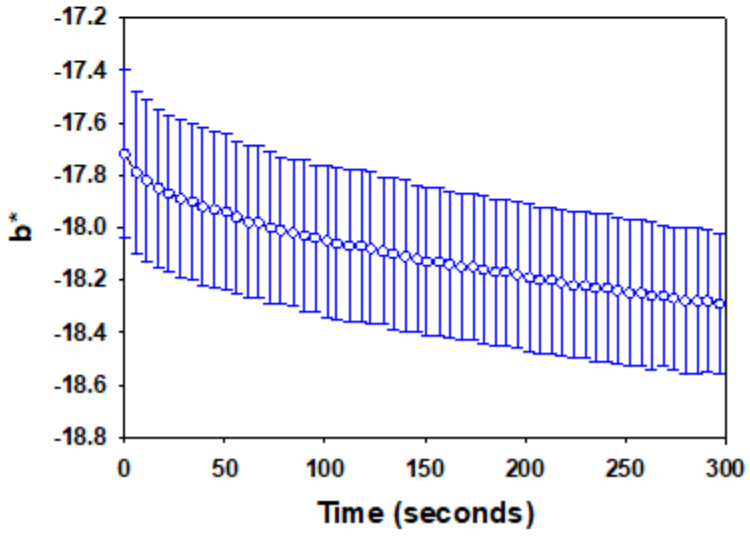
Paper



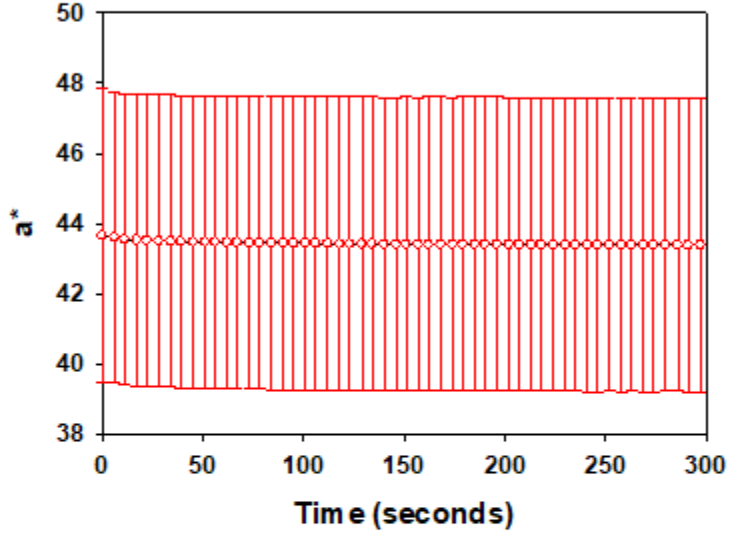


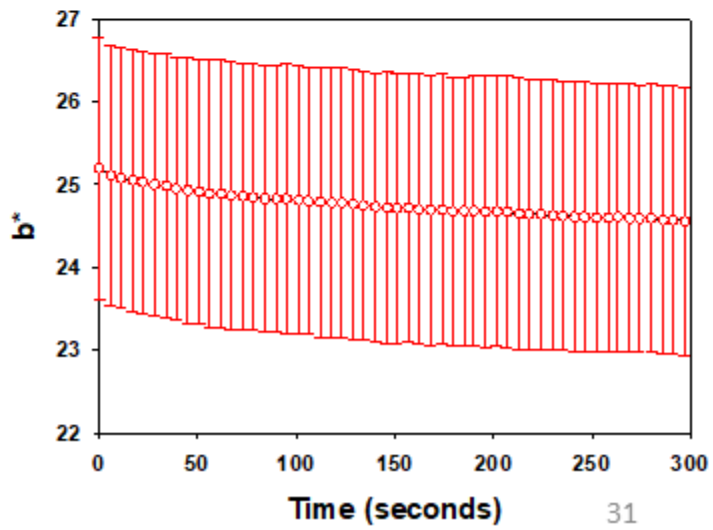
Blue

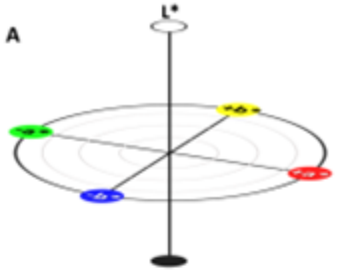




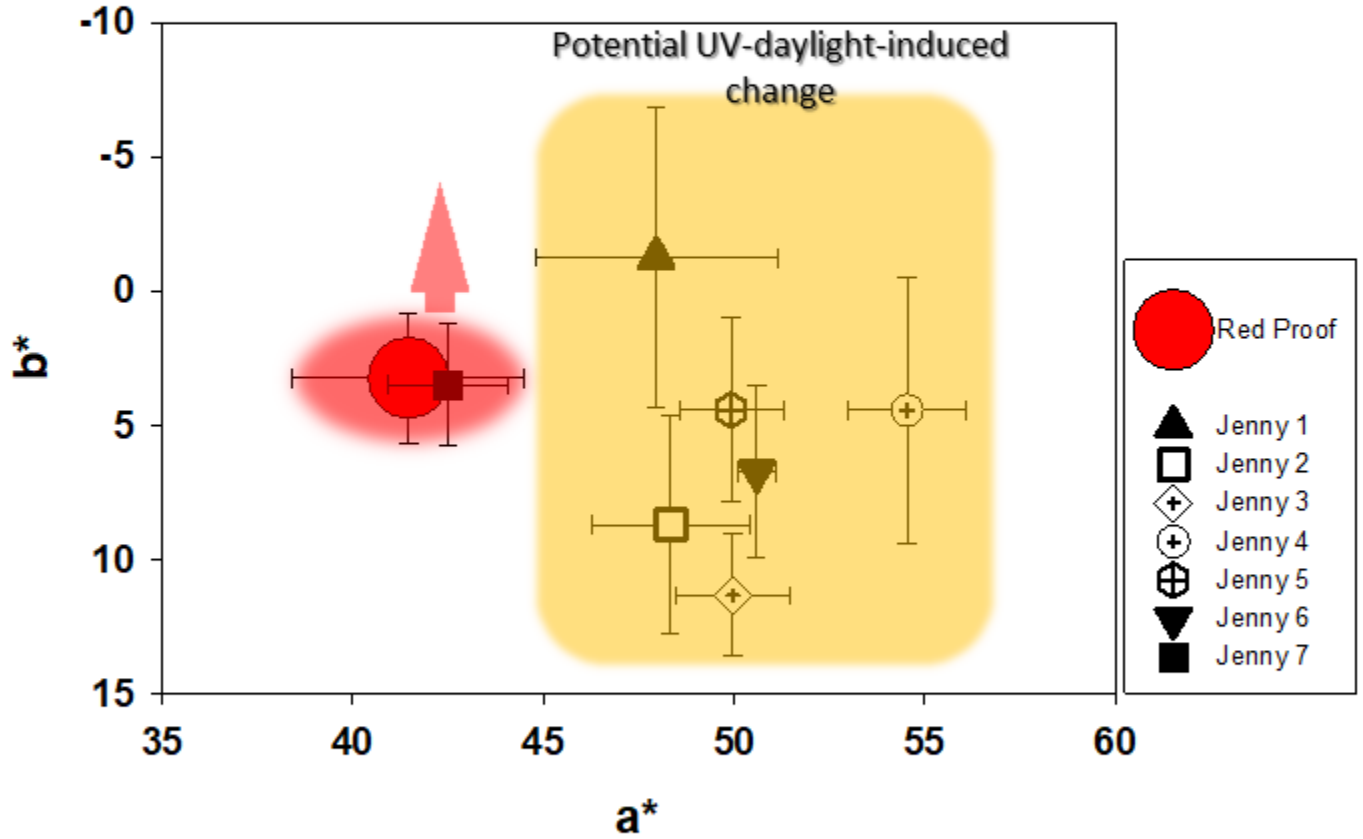
Red







MFT Interpretation for the Red



Calculation of Light Exposure

Each view 20 seconds

-

Calculation of Light Exposure

Each view 20 seconds

	≈ Exposure for a Day
100 views/day	0.56 h
250 views/day	1.4 h
500 views/day	2.8 h
1,000 views/day	5.5 h

Calculation of Light Exposure

Exposure
At 26.9 Candela Steradians or lux

Each view 20 seconds	≈ Exposure for a Day
100 views/day	0.56 h
250 views/day	1.4 h
500 views/day	2.8 h
1,000 views/day	5.5 h

Calculation of Light Exposure

Each view 20 seconds	≈ Exposure for a Day	Exposure At 26.9 Candela Steradians or lux 10 yr Calculated Maximum Light Exposure
100 views/day	0.56 h	0.056 Mlux·h
250 views/day	1.4 h	0.14 Mlux·h
500 views/day	2.8 h	0.27 Mlux·h
1,000 views/day	5.5 h	0.55 Mlux·h

Well below the 1.2 Mlux*h, which is the max that blue wool 2 can handle (based on experimental data)

Conclusions & Future Work

Through color simulation and color reference tiles, we gained confidence of the color measurements in VSC and MFT

Gained an understanding for the statistical spread of the colors within the 1918 Jenny Stamps

By understanding the statistical spread we were able to further interpret the MFT data

The calculated projected light exposure affirms the conservative NPM lighting is successfully protecting the Inverted Jenny

Further study the on the inorganic and organic chemistry of the stamp

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Thank you!

Questions?