

Colorimetric Analysis of the Farnsworth-Munsell D-15 Color Vision Test in Trichromatic And Dichromatic Color Spaces

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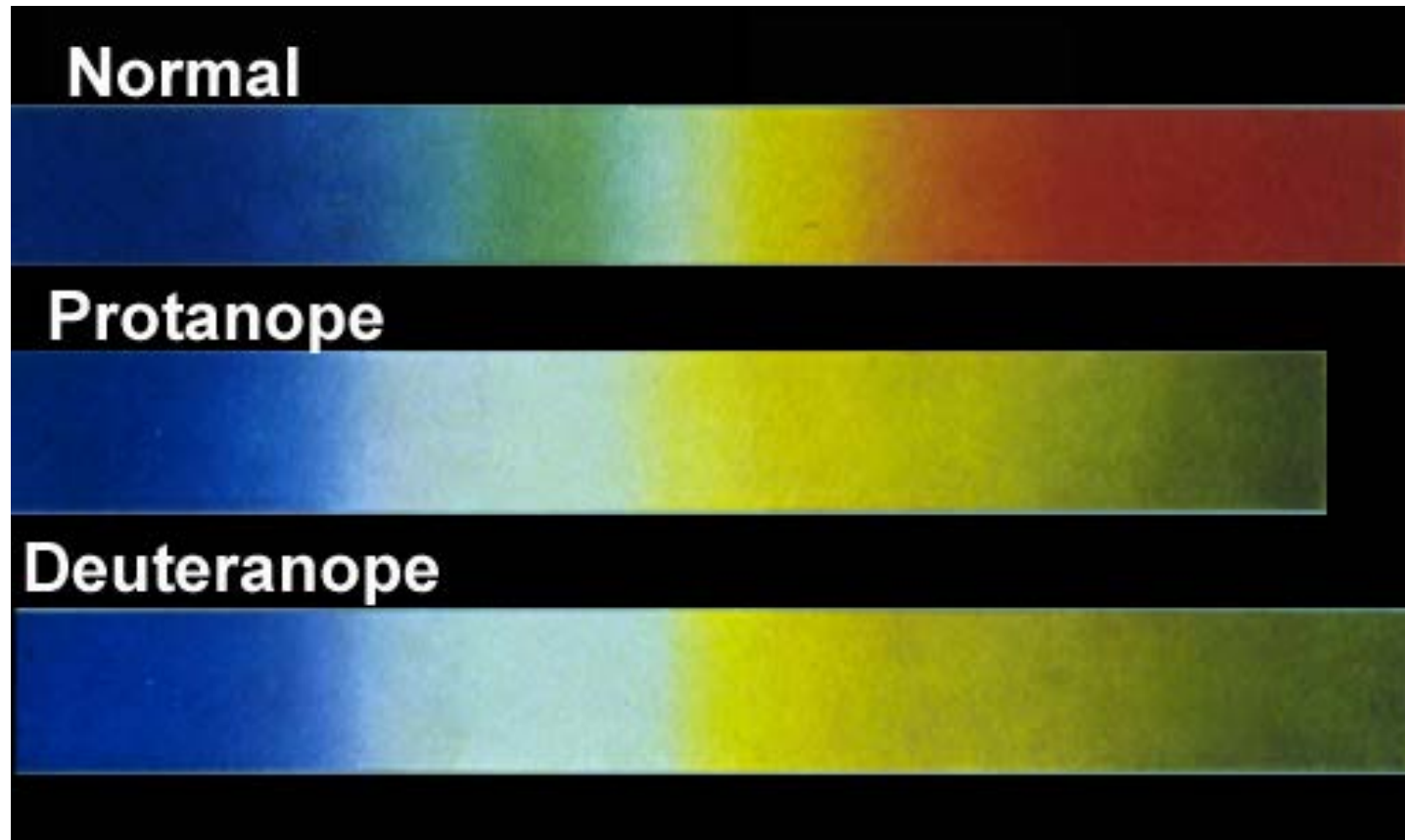
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Introduction

- 👁️ Continuing interest to illustrate how individuals with congenital color vision defects perceive colors



Missing L-cone

Missing M-cone

From Trendelenburg, 1952

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OPTOMETRY & VISION
SCIENCE

Based on a Neural Network



Normal



Protanopia



Deuteranopia

From Usui & Nakauchi, 1993

Web based simulations

Color Blindness Simulator

If you are not suffering from a color vision deficiency it is very hard to imagine how it looks like to be colorblind. The **Color BLIn**dn^es^s Simulator can close this gap for you. Just play around with it and get a feeling of how it is to have a color vision handicap.

As all the calculations are made on your local machine, no images are uploaded to the server. Therefore you can use images as big as you like, there are no restrictions. Be aware, there are some issues for the "Lens feature" on Edge and Internet Explorer. All others should support everything just fine.

So go ahead, choose an image through the upload functionality or just drag and drop your image in the center of our **Color BLIn**dn^es^s Simulator. It is also possible to zoom and move your images around using your mouse – try it out, I hope you like it.

Drag and drop or paste your file in the area below or: No file chosen

Trichromatic view:	Anomalous Trichromacy:	Dichromatic view:	Monochromatic view:
<input type="radio"/> Normal	<input type="radio"/> Red-Weak/Protanomaly	<input type="radio"/> Red-Blind/Protanopia	<input type="radio"/> Monochromacy/Achromatopsia
	<input type="radio"/> Green-Weak/Deuteranomaly	<input checked="" type="radio"/> Green-Blind/Deuteranopia	<input type="radio"/> Blue Cone Monochromacy
	<input type="radio"/> Blue-Weak/Tritanomaly	<input type="radio"/> Blue-Blind/Tritanopia	

Use lens to compare with normal view: No Lens Normal Lens Inverse Lens
[Reset View](#)

FREE Color Blind Check

New kind of color blindness test! Try **Color Blind Check** and test type and severity of your color vision deficiency. Easy and fun!
Info at www.colorblindcheck.com

ANDROID APP ON

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Conversion Algorithm (Brettel et al. J Opt Soc Am (A) 1997)

- 👁️ Measure 1931 X, Y, Z tristimulus values of the objects
- 👁️ Convert to L-, M-, S-, cone responses
- 👁️ Convert L, M, S responses to dichromatic cone responses
 - Protanope – just S & M cones
 - Deuteranope – just S & L cones
 - (colors on a line a parallel to the M-cone axis are represented as a point in a S-cone-L-cone plane)
- 👁️ Convert to dichromatic X_D , Y_D , Z_D values
- 👁️ Both Color-Normal and Dichromatic X, Y, Z values were transformed to CIELAB coordinates

The issue

Previously

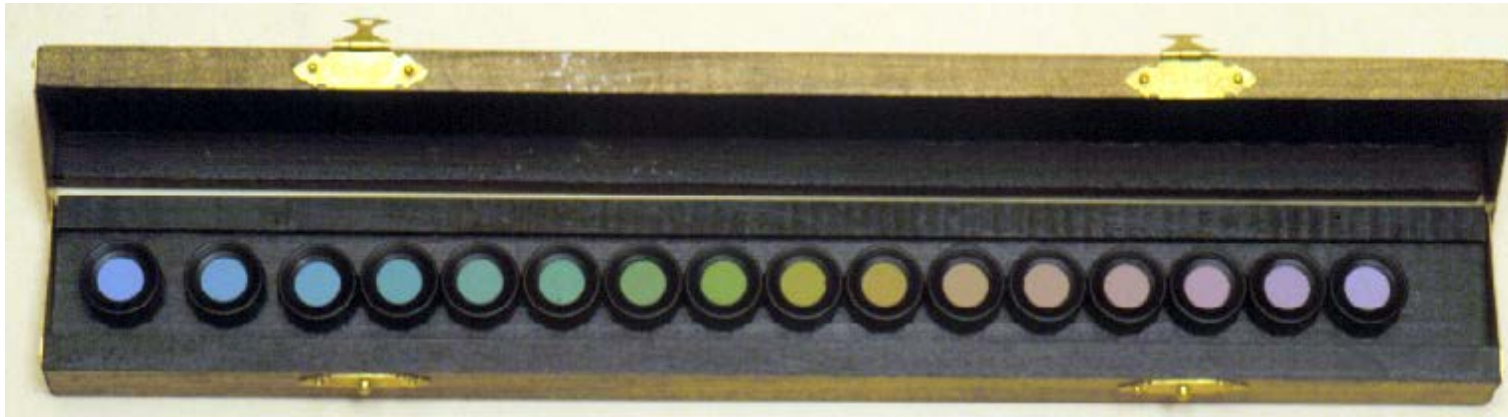
- Used this transformation $L^*a^*b^*$ space to determine whether the calculated dichromatic color differences correlated with color naming errors
- But the correlation was low-to-moderate
 - colored objects had brightness differences also

Would this transformation be successful in predicting the dichromatic arrangements for the D-15?

- luminance differences between caps are small
- the primary task is hue discrimination.

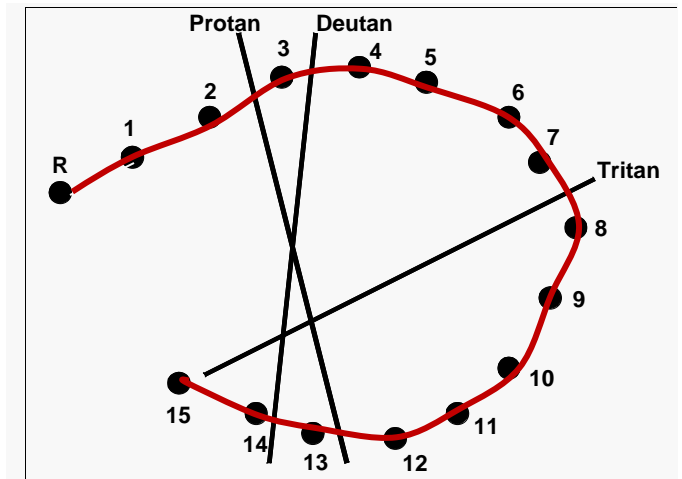
The “objects”

Farnsworth-Munsell D15



Remove loose caps

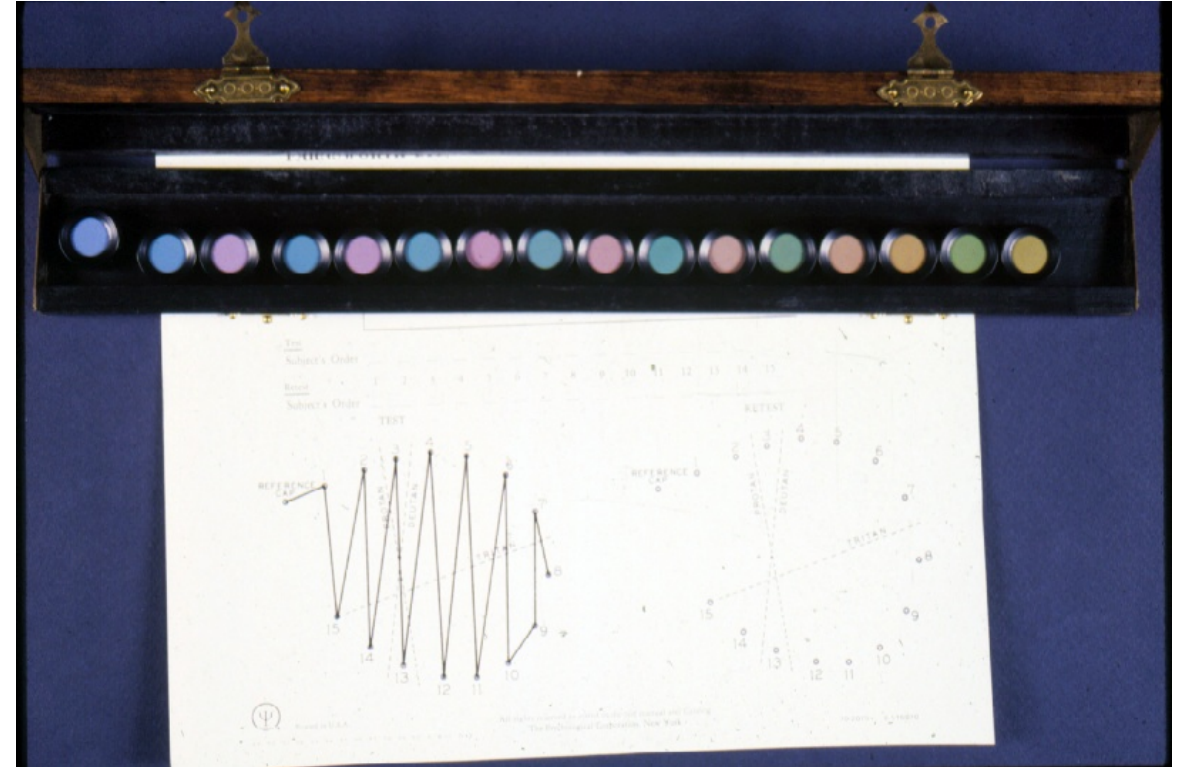
- “place the loose cap that is most similar in color to the last one placed in the box”



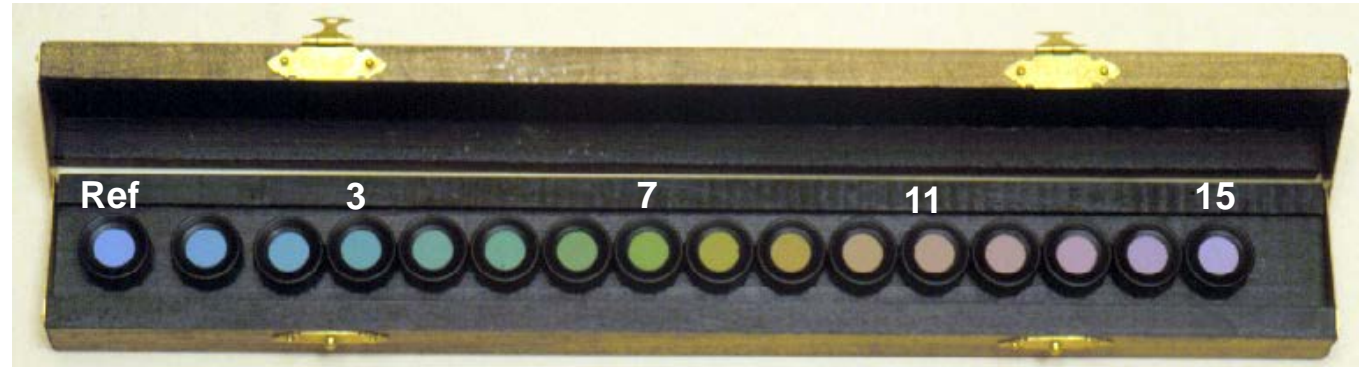
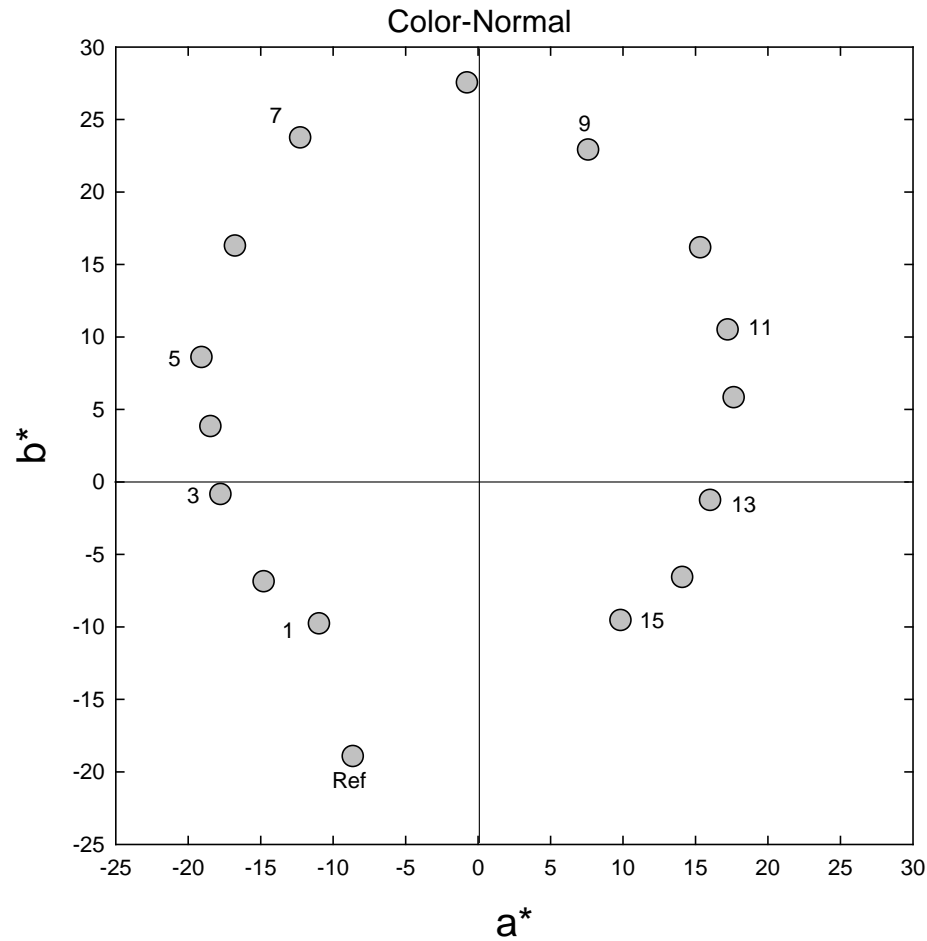
Protanopic Arrangement



Deuteranopic Arrangement



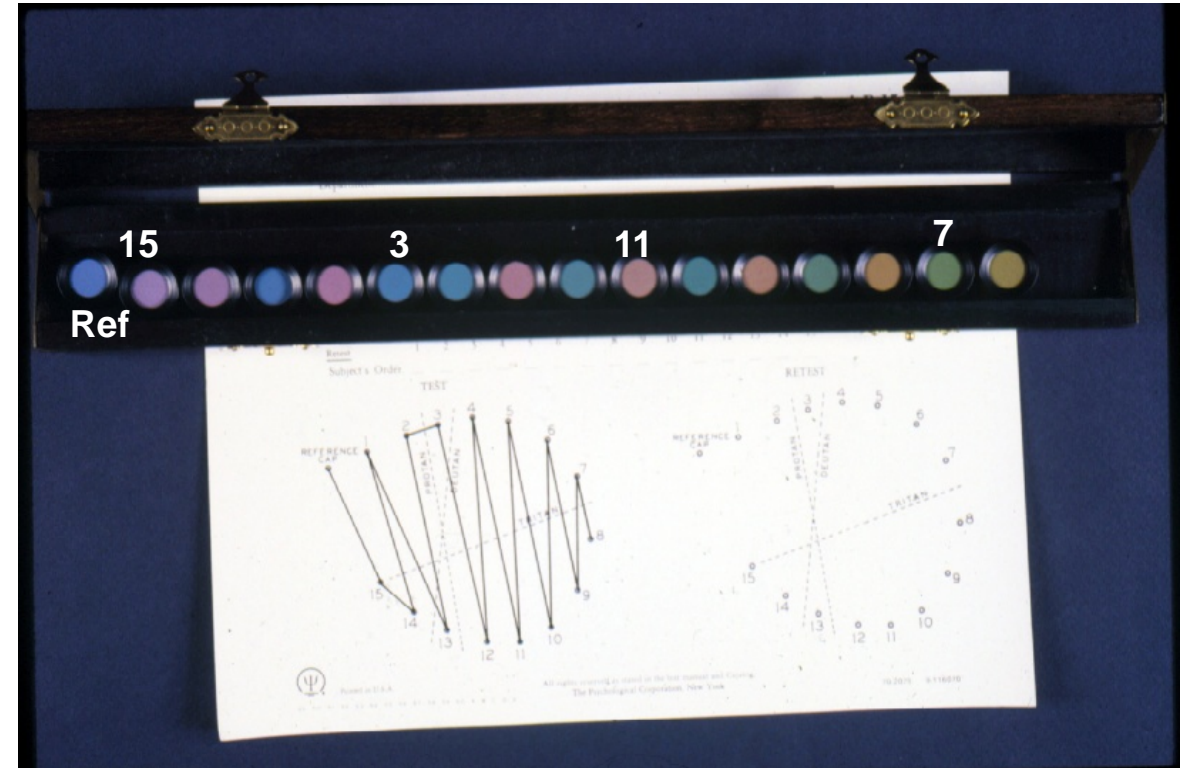
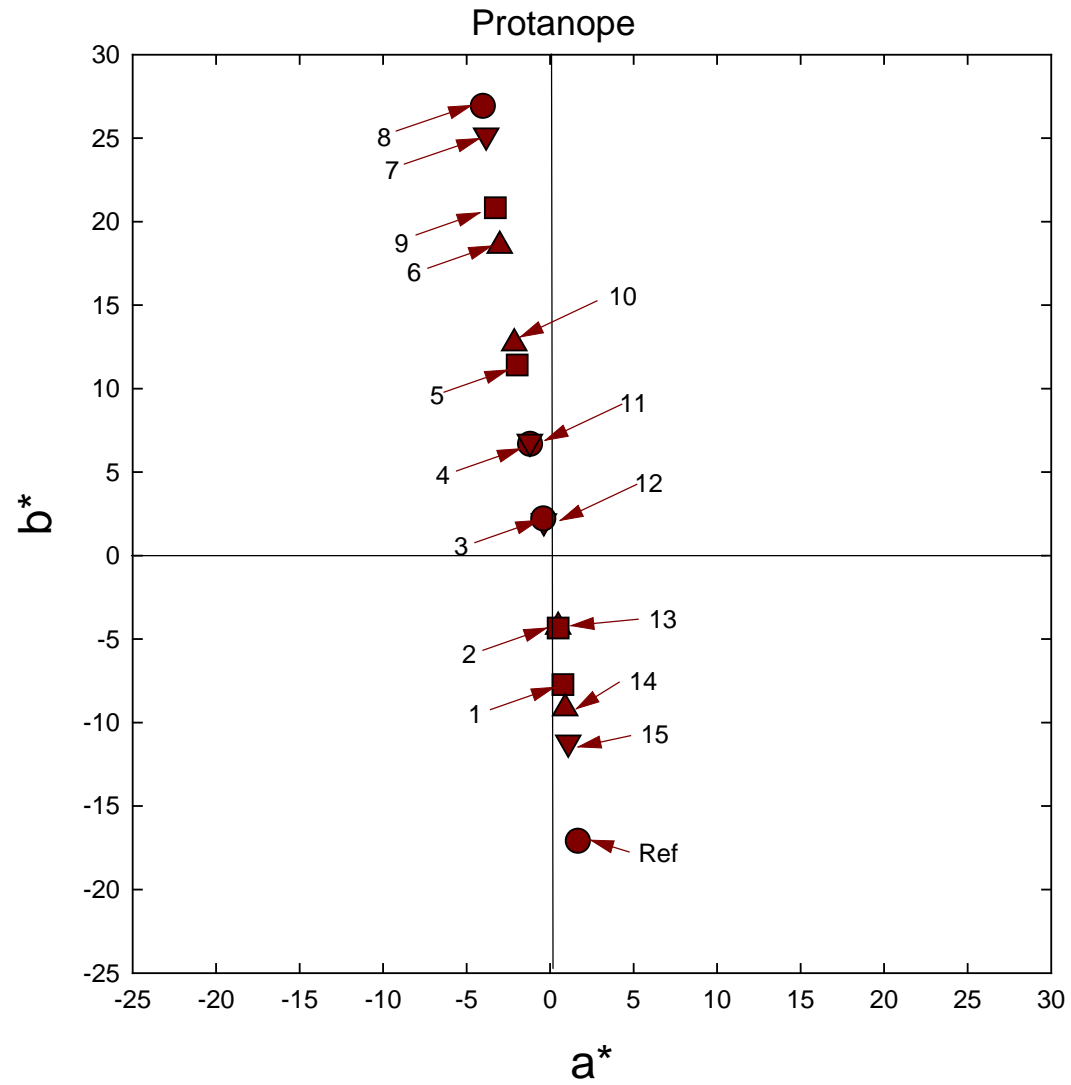
Plotted in CIELAB



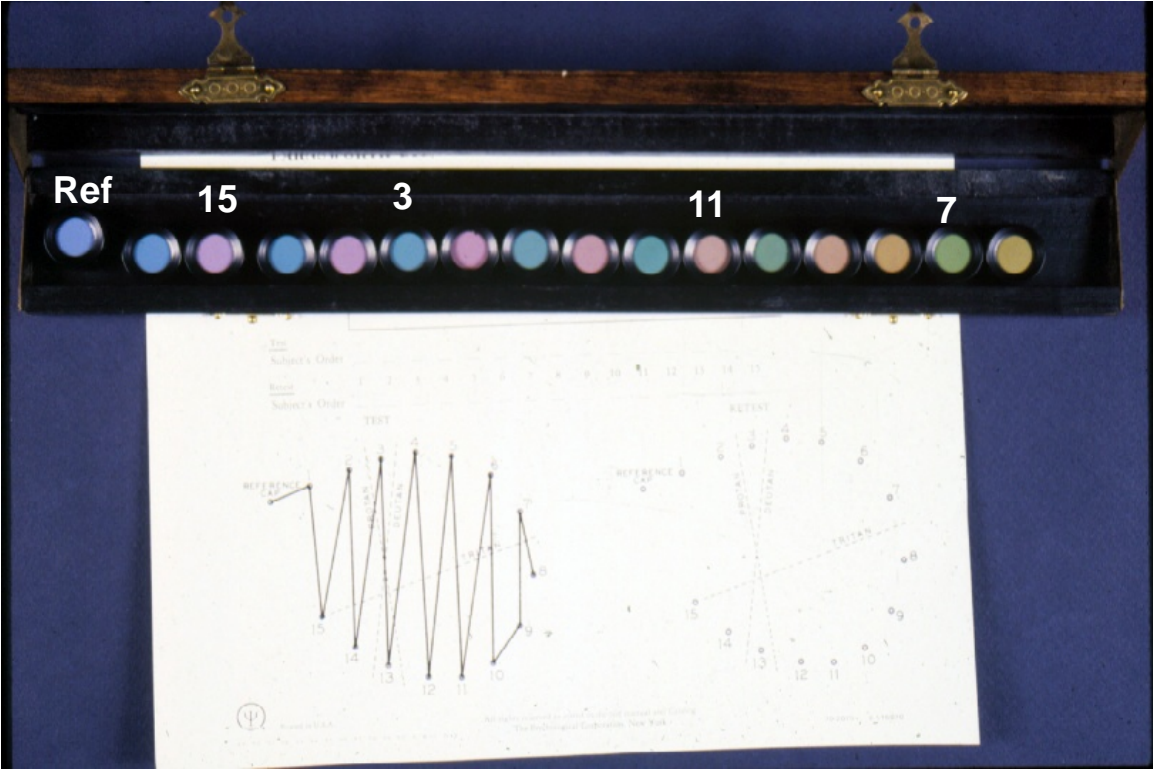
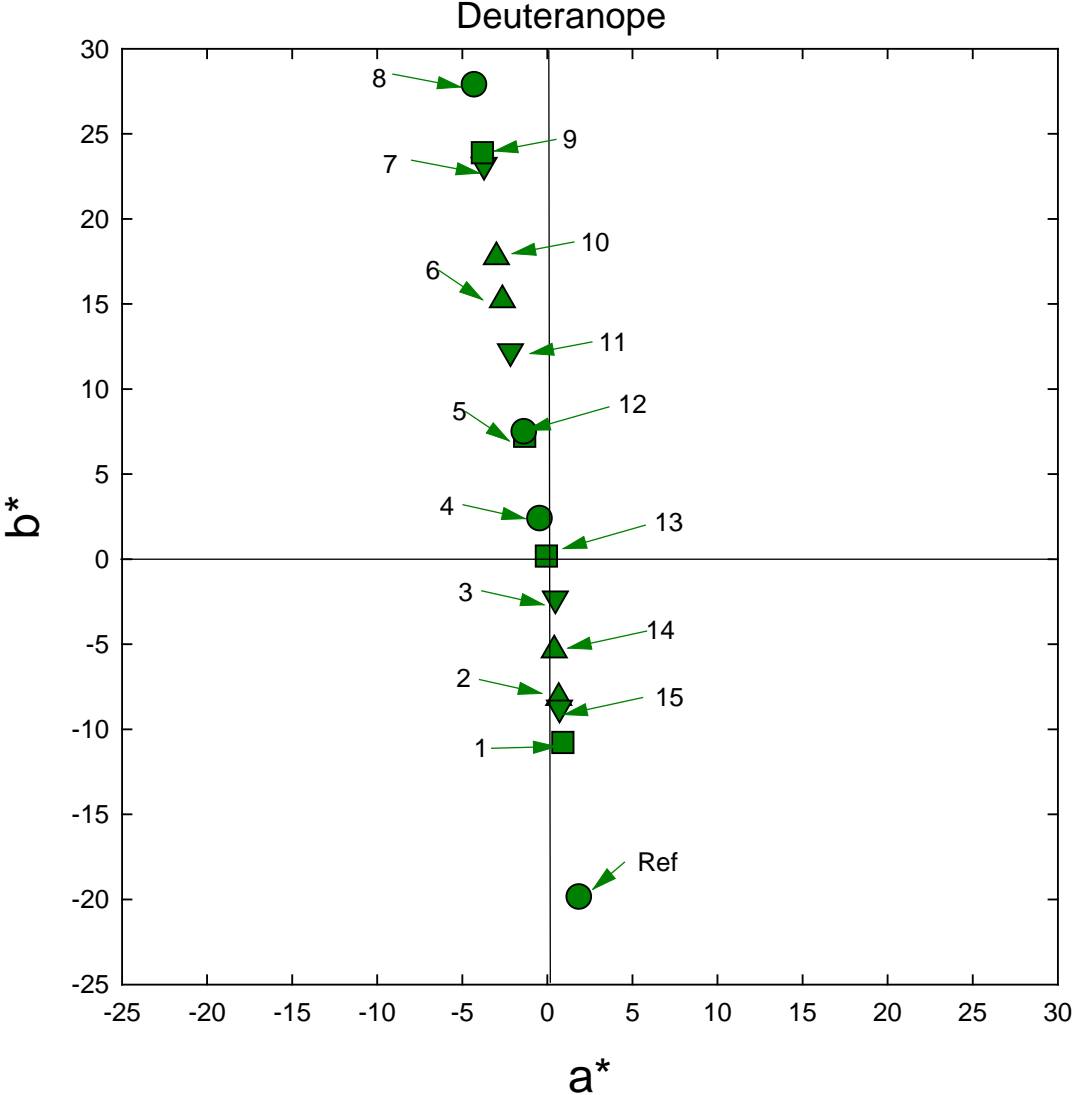
- **Theoretical Arrangement**

- select the “loose” cap with the smallest ΔE relative to the one in the box

Protanope



Deuteranope

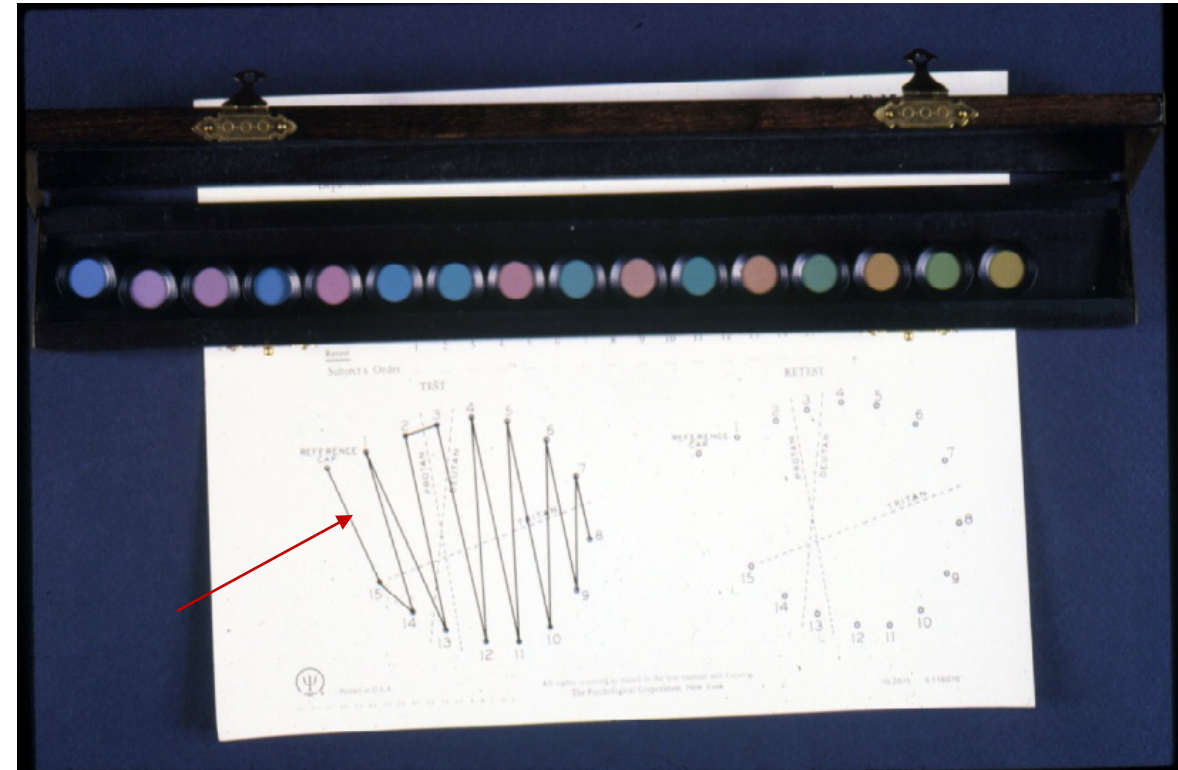
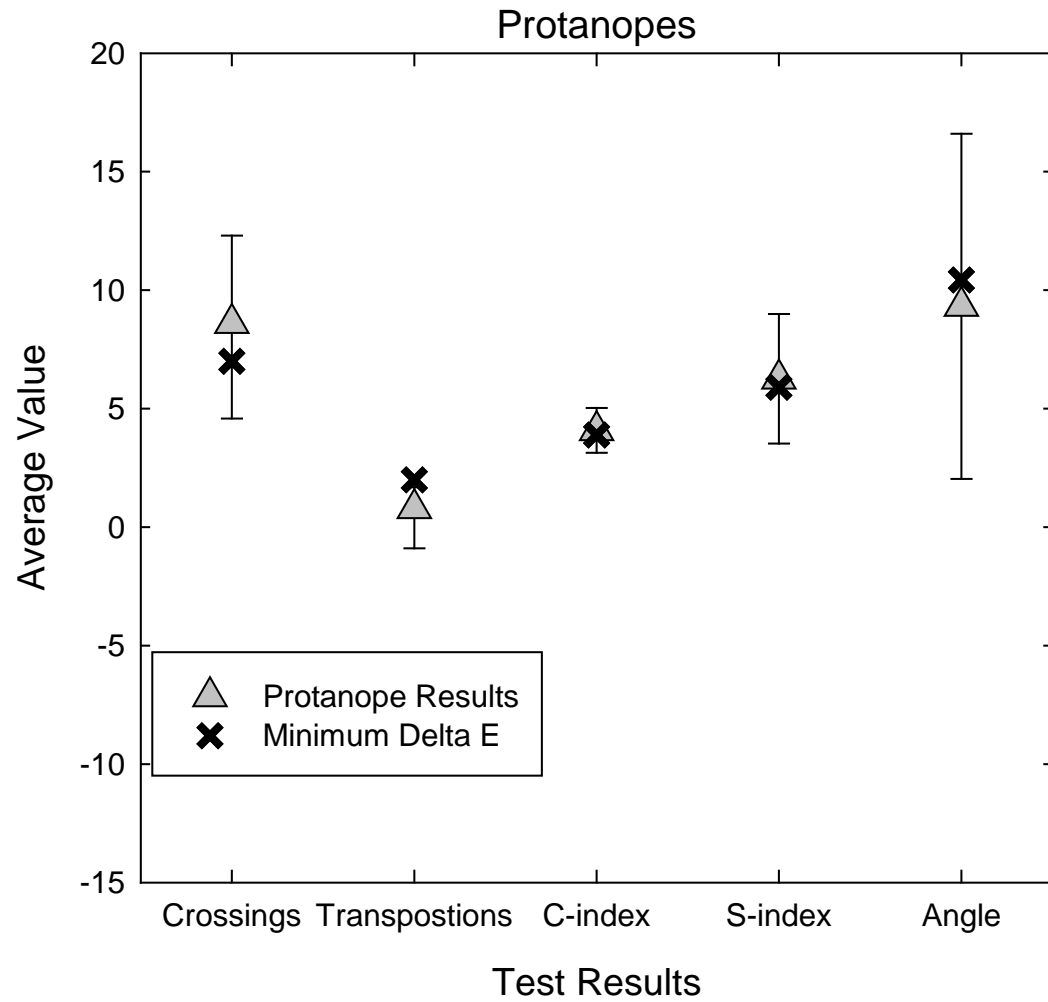


Subjects

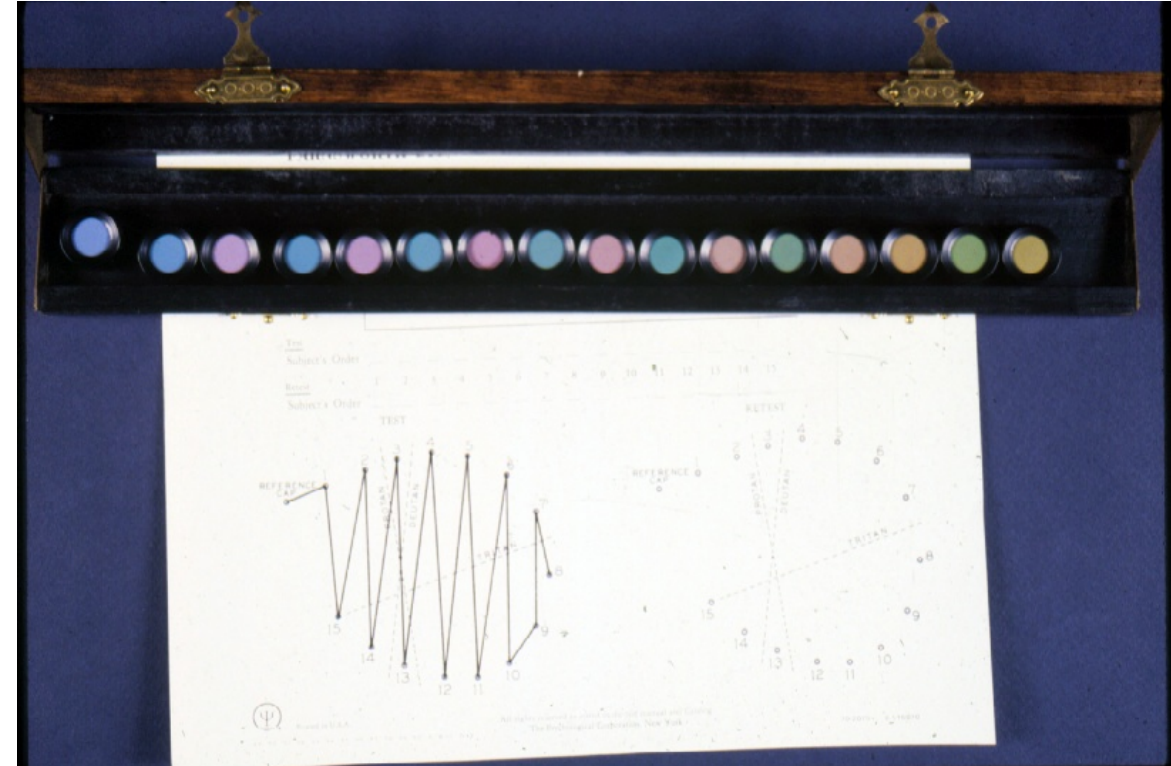
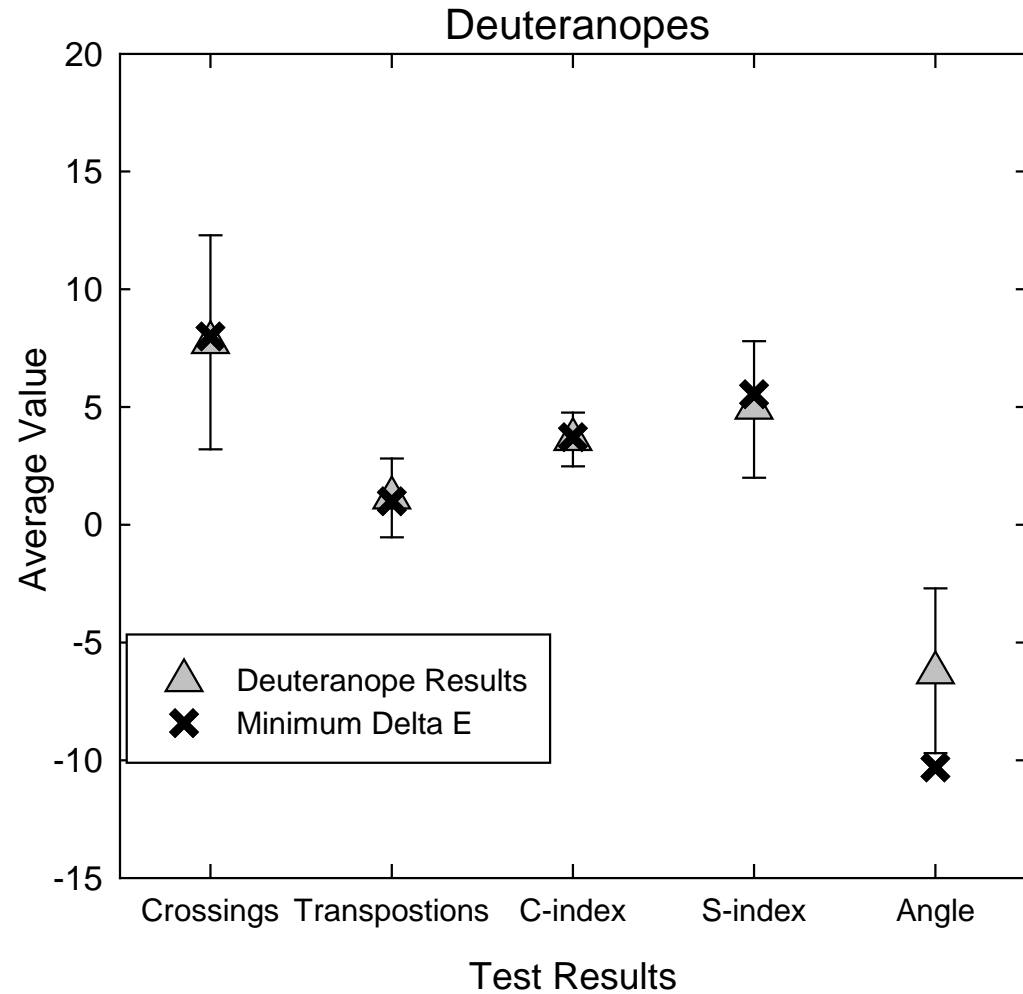
 **The predicted arrangements were compared with the results from**

- 8 deuteranopes (no M-cones)
- 19 protanopes (no L-cones)

Protanopes



Deuteranopes



Conclusions

- 👁️ **Translating the Farnsworth D15 colored caps into dichromatic CIELAB space provides a very good prediction of protanopic and deuteranopic arrangements**
- 👁️ **Although the translation may not be optimal to predict color naming errors when brightness differences are present, this approach is useful in predicting/illustrating dichromatic hue discrimination**

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