



Evaluation of Unique Hue Predictions in CIECAM02 by using Unique Hue Data

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OVERVIEW

- q **Introduction**
- q **Psychophysical Experiment**
- q **CIECAM02 Prediction**
- q **Discussions**
- q **Conclusions**



Unique Hues

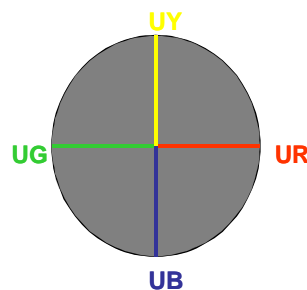
were originally defined by Hering as

Unique Red: Neither Yellowish nor Blueish

Unique Green: Neither Yellowish nor Blueish

Unique Yellow: Neither Reddish nor Greenish

Unique Blue: Neither Reddish nor Greenish



Unique Hues for Colour Appearance Model

- q Acknowledged in accessing colour appearance data
- Magnitude Estimation Experiment



70%Y 30%R
H=30

- q Built in colour appearance model for transform
between hue angle (h) and hue composition (H)
- q Significant affect performance of hue prediction in
colour appearance model



Unique Hues in Colour Appearance Models

UH	UR	UY	UG	UB
RLAB	24	90	162	246
LLAB	25	93	165	254
Hunt	20	90	164	238
CIECAM97	20	90	164	238
CIECAM02	20	90	164	238

All based on notation of the Swedish Natural Colour System (NCS)

Are unique hues well represented in CAMs?



Aim of This Study

q To study and report on unique hue data, including an analysis of the scatter of those data: this to include practical viewing conditions (CIE TC 1-76).

q To evaluate Unique Hue Predictions in CIECAM02

- under various ambient lighting conditions
- using self-luminous Colours compared to surface colours



EXPERIMENT

Equipment

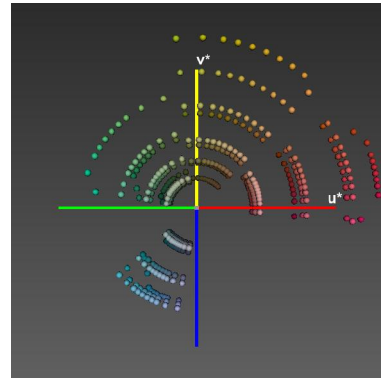
A CRT monitor (21-inch Sony GDM-F520) which was controlled by a DELL PC with a ViSaGe graphics card (Cambridge Research System, Ltd.).

CRT

A D93 CRT monitor was characterised by ColourCal calibration device (and checked with a PR650)

Test Samples

360 test colour samples were selected
9 chroma-lightness level for each unique hue in CIELUV uniform colour space



EXPERIMENT

Unique Hue Selection Task

Observer was asked to select a patch on the CRT that contains neither yellowish nor blueish (to obtain unique red and green). Unique yellow (blue) was obtained by asking observers to select a patch that contains neither reddish nor greenish.

Subjects

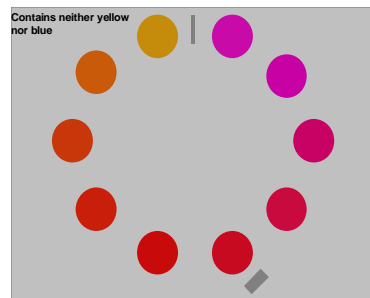
185 naïve observers with normal colour vision (Cambridge Trivector Test)

Repetition

Three times

Viewing Condition

Dark Room, D65, CWF





EXPERIMENT

GTI ColorMatcher GLE M5/25



CRT under D65



CRT under CWF

Room Lighting	Lum	x	y	CCT
D65	41.3	0.3229	0.3453	5917
CWF	136.8	0.3890	0.3887	3866



RESULTS

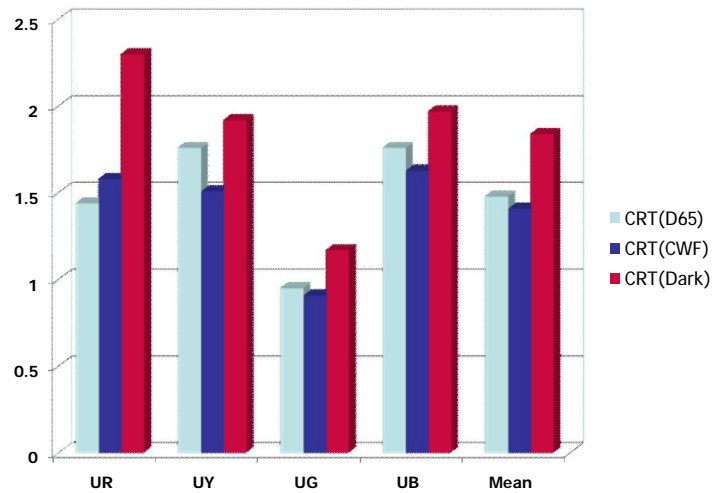
Unique Hue Data

- q Each unique hue stimulus was measured with a PR-650 tele-spectroradiometer to obtain the CIE XYZ tristimulus values
- q Unique Hue stimuli assessed by 185 subjects in 3 repetitions were averaged
- q Three groups of Unique Hue Data (9 x 4 UHs)
 - Dark Room
 - under D65 room lighting
 - under CWF room lighting



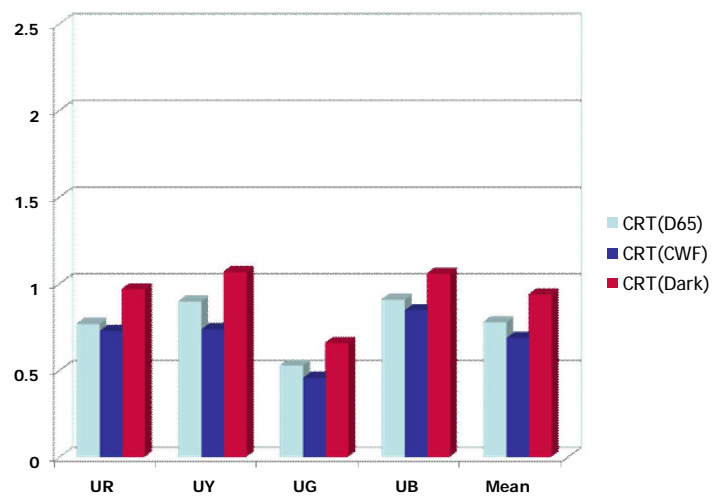
RESULTS

Inter-Observer Variability (ΔE_{00})



RESULTS

Intra-Observer Variability (ΔE_{00})



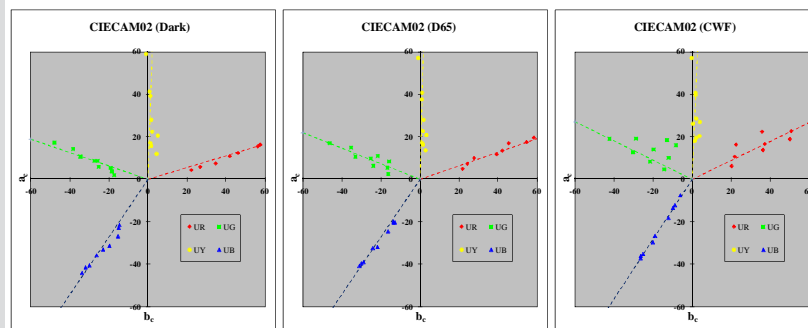


Colour Appearance Prediction

Inputting Parameters for CIECAM02

CIECAM02	X_w	Y_w	Z_w	L_w	Y_b	Surrounding
CRT (Dark)	98.0	100.0	139.7	114.6	20	Dim
CRT (D65)	97.4	100.0	138.2	117.1	20	Average
CRT (CWF)	97.7	100.0	134.2	121.4	20	Average

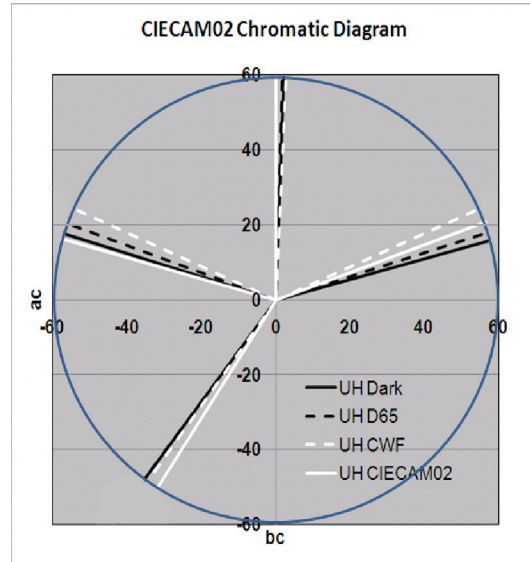
Monitor white point under dark room or room lighting condition were measured by TSR as adopted white point



Unique hue lines in the CIECAM02 chromatic diagram



UNIQUE HUES in CIECAM02



UNIQUE HUES in CIECAM02

Unique Hue Angles in CIECAM02

Hue Angle (h)	UR	UY	UG	UB
NCS	20.1	90	164.3	237.5
UH-Dark	15.4	88.0	162.7	233.6
UH-D65	17.7	83.3	159.9	234.0
UH-CWF	23.5	84.0	151.0	234.6



Effect of Viewing Condition on Hue Difference

ΔH	UR	UY	UG	UB
Dark vs. D65	3.3	0.6	3.3	0.8
Dark vs. CWF	8.3	1.3	9.2	1.1

$$\overline{\Delta H} = \frac{\sum_{i=1}^9 |\Delta H_i|}{9} \quad \text{Where} \quad \Delta H_i = 2\sqrt{C_{Ri}C_{Ti}} \sin\left(\frac{h_{Ri} - h_{Ti}}{2}\right)$$



Unique Hue in CIECAM02

q NCS Unique hue is not accurate enough

q Not Uniform

- Modify uniform colour space

q Not independent of various viewing conditions

- Modify Chromatic Adaptation Transform
- Mixed adaptation model



SUMMARY and CONCLUSIONS



- q Unique hue data under three viewing conditions were obtained on a CRT using a large sample of colour-normal observers (n=185)
- q Observer variability is low, inter-observer variability $<2 \Delta E_{00}$, intra-observer variability $<1 \Delta E_{00}$ for the three viewing conditions
- q There are discrepancies between the default NCS unique hues and our data
- q CIECAM02 predictions for different illumination conditions are not consistent for UG, and to a slightly lesser degree, for UR; UY and UB are predicted accurately by CIECAM02.



Thanks!