The Norwegian
Colour and Visual Computing
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Substrate adaptation: can we simulate this with soft proofing?

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Motivation

- Examine **media-relative colorimetry** in isolation from other constraints, as part of a Graphic Arts approach to *common colour appearance*
- Examine Graphic Arts application of mixed adaptation, in particular for reproductions on different substrates
- Assess soft-proofing for delivering future work relating to print appearance

Typical display application

- Use a chromatic adaptation transform (CAT) to predict a corresponding colour under different illuminants via LMS cone space
- Typically used to map display colorimetry relative to the display whitepoints
- Somes CATS allow for incomplete or mixed adaptation in their calculation (usually variable ‘D’)

Typical print application

- Assumes a D50 illuminant for all colorimetry
- Use an ICC Media Relative transform (XYZ normalisation) to modify print colorimetry relative to two paper whites
- Assumes either full adaptation to reproduction substrate (media-relative) or no adaptation (an absolute colorimetric match to original)

Chromatic adaptation – physiological

Physiological – sensory based

- Light and dark adaptation
  (overall level of illumination)
- Chromatic adaptation (cone receptor gain control, analogous to white balance)
- Simultaneous colour contrast
  (opponency-based chromatic induction)

Chromatic adaptation – cognitive

Cognitive – object appearance under prevailing lightsource may be overridden by:

- Memory colours (sky blue, skin tones, etc.)
- Preference (warm or cool neutrals, etc.)
- 'Cognitive discounting of the illuminant' (resulting in incomplete adaptation to lightsource whitepoint)

Experimental Objectives

- To separate physiological and cognitive aspects of the adaptation
- To test the conceptual nature of substrate-relative appearance-matching in a soft-proof
- To quantify degree of adaptation to a reproduction substrate for a given use case where the only variable is the image content

User interface – degree of adaptation

Adopted WP
D50 chromaticity
120cd/m^2
Lab=[100,0,0]

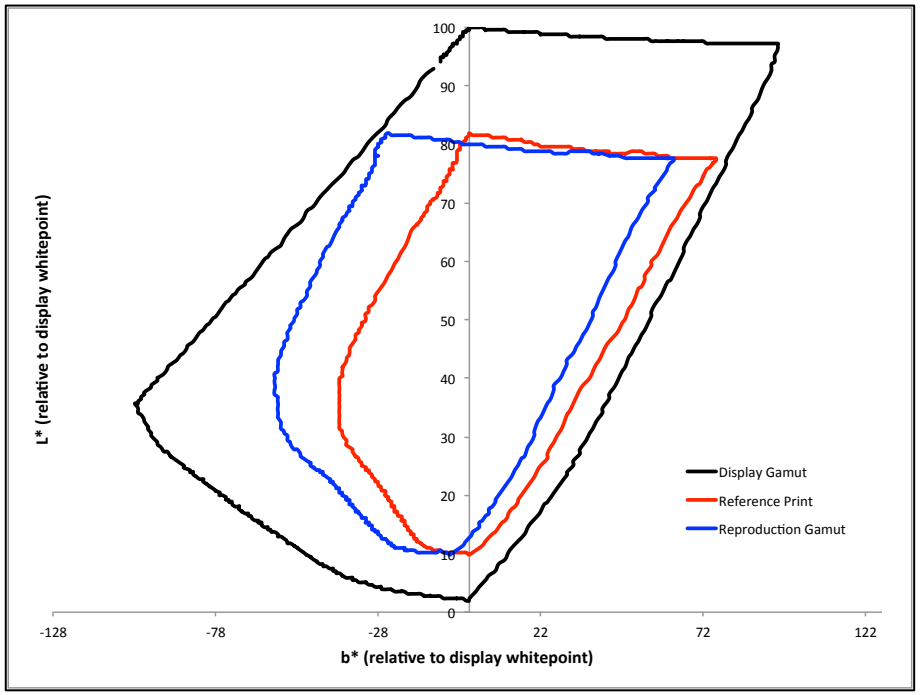
120cd/m^2
Lab=[100,0,-30]

Grey surround
D50 chromaticity
Lab=[50,0,0]

- Observers use a 'virtual slider'
- Degree of adaptation is adjusted between Abs. Colorimetric and Media Relative

Achieving a simulation of two substrates

- Matlab-based software uses an XYZ-based connection space
- Custom ICC profiles built for SWOP-like print outputs
- If absolute luminance of display whitepoint is known then all colorimetry can be calculated
- Software uses DeviceLink-like LUTs for computational efficiency



• **Gamut projection – simulation of two substrates on a D50 display**

Print appearance simulation task

Printed on to the Blue Paper.

You are now asked to imagine how the reference image would look if it were printed on the blue paper.

You should adjust the reproduction image to look as though it is printed directly onto the blue paper.

Hint: Usually, the lightest/whitest part of the image is close to the colour of the unprinted paper

- Additional training time & images were provided to observers prior to the experiment in order for them to develop their matching strategies
- Realworld print on high chroma paper provided as a reference

Results – print appearance task

Adjust reproduction to have an appearance as though it was printed on the blue paper

Degree of adaptation D where D=1 means reproduction substrate adapted, or a media relative match
where D=0 means reference substrate adapted, or an absolute colorimetric match

Image Name	**IMAGE_01**	**IMAGE_02**	**IMAGE_03**	**IMAGE_04**	**IMAGE_05**	**IMAGE_06**	**IMAGE_07**	**IMAGE_08**	**IMAGE_09**	**IMAGE_10**	**IMAGE_11**
Image Type	Colour	Colour	Colour	Colour	Colour	Colour	Colour	Colour	Greyscale	Greyscale	Greyscale

												MIN	**MAX**	**MEAN**
Mean D	**1.24**	**1.11**	**1.17**	**1.06**	**1.08**	**0.92**	**0.96**	**1.06**	**1.16**	**1.18**	**1.16**	**0.92**	**1.24**	**1.10**
Std.Dev.S	0.23	0.28	0.46	0.22	0.19	0.33	0.43	0.28	0.34	0.15	0.15	0.15	0.46	0.28
95% Conf.Int.	0.12	0.14	0.23	0.11	0.10	0.17	0.22	0.14	0.17	0.08	0.08	0.08	0.23	0.14

- Two out of sixteen observers failed to understand task (reverted to colorimetric match)
- Could not accurately mimic a media-relative (printed on blue paper) reproduction
- Over-rode local adaptation in specular highlights to ‘force’ highlights to visually match blue substrate

Conclusions

- Creating a soft-proof substrate-relative appearance match requires a conceptual understanding of print-on-paper
- Without the visual clues of a hardcopy observers are unable to make a media-relative appearance match on screen

Conclusions

- Soft proofing does not lend itself to print approval or adjustment task involving change of substrate
- Substrate-relative print reproductions must be assessed with hard-copies

Current & future works

- Paper on content-dependent adaptation (observed in on-screen visual matching experiments)
- Adaptation found to be highly dependent on image lightness and neutrality
- Work to be extended for content-dependent adaptation in hard copy prints

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Thank you for your attention

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