

Assessing color reproduction tolerances in commercial print workflow

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The nightmare of ICC profiles

- ▶ the ICC profile standard has **no provisions for workflow**
- ▶ oftentimes embedded profiles are incorrect
- ▶ oftentimes profiles are of poor quality
- ▶ workflow system must be able to swap out profiles
- ▶ want to target good enough quality for given price point (SLA)
- ▶ select relevant papers:
 - ▶ Lammens, “Night of the living color: horror scenarios in color management land,” this conference 1998
 - ▶ Phillips et al., “Comparing image quality of print-on-demand books and photobooks from web-based vendors,” JEI 2010
 - ▶ Beretta et al., “ICC profiles: are we better off without them?” this conference 2011
 - ▶ Falkenstern et al., “Adaptively selecting a printer color workflow,” NIP 2011



Assessing print quality

- ▶ average ΔE values are not useful
- ▶ a useful metric must allow specific assessment
- ▶ Peter Zolliker et al. from EMPA have proposed several more useful methods
- ▶ is there a simpler method?



Color fidelity vs. color integrity

- ▶ in practice, color fidelity is not that critical
- ▶ Phillips et al., “Comparing image quality of print-on-demand books and photobooks from web-based vendors,” JEI 2010
- ▶ print does not contain sets of unrelated colors but color palettes
- ▶ **goal:** preserve the integrity of color palettes

Example (catalog selling denim garments)

One page might have jeans in original, washed, and stone-washed denim, while a second page might have corresponding jackets. The specific hue of each garment is less important than being able to match jackets to jeans while preserving the rank of the processes



Farnsworth-Munsell 100-hue test

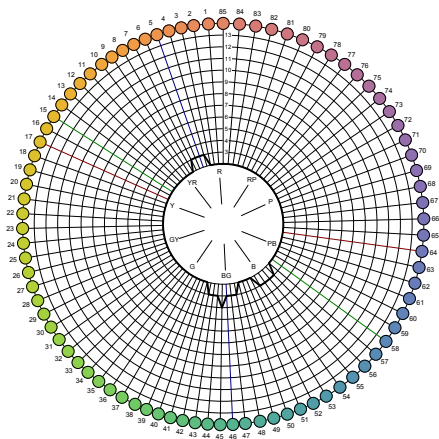
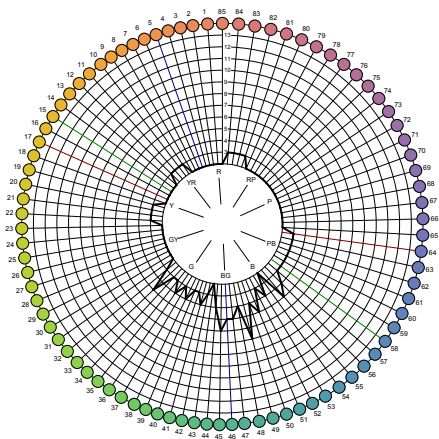
- ▶ in the case of humans, color discrimination can be assessed with the Farnsworth-Munsell 100-hue test
- ▶ can we use this test for color reproduction systems?



Scoring transpositions



Graphical evaluation



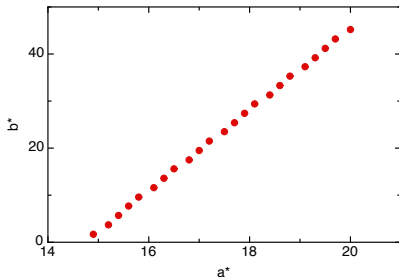
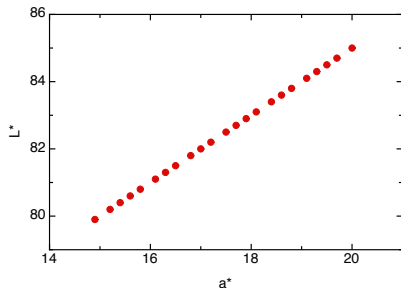
Practical application

- ▶ FM-100 assesses entire hue circle
- ▶ we need to assess only the critical color ranges
- ▶ include one or more scales in the crop margin
- ▶ normalize scores to FM-100
- ▶ examples of parameters to assess:
 - ▶ ICC profile plausibility & correctness
 - ▶ ICC profile reputation & precision
 - ▶ rendering intent
 - ▶ gamut mapping algorithm
 - ▶ black skeleton
 - ▶ halftoning
 - ▶ inks, process vs. Hexachrome; spot colors
 - ▶ media



Example

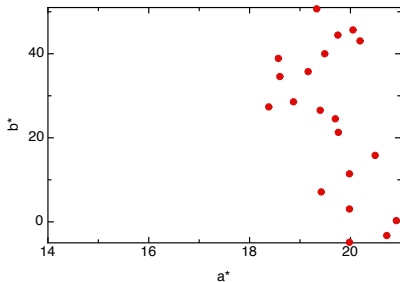
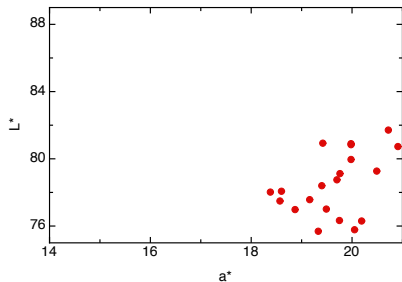
A uniform color scale in CIELAB from (80, 15, 2) to (85, 20, 45)



The non-uniformities are due to rounding the coordinates to one decimal digit

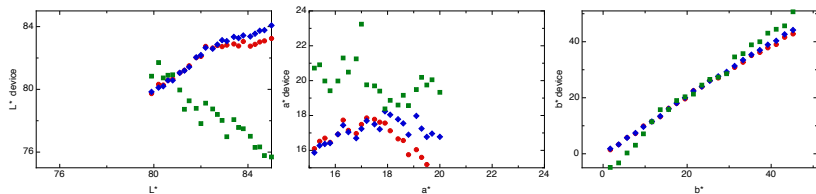


Reproduction on office laser printer



$$\Delta E_{94} = 5.6$$

Comparison of 3 devices



ΔE_{94} :

- ▶ green device: 5.6
- ▶ red device: 1.2
- ▶ blue device: 0.7



Physical vs. simulated

