Translating Albers to CAM16: a Case for Next-Generation Color Pickers

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ABSTRACT

The universally taught art-educational material *Interaction of Color* by Josef Albers is used to form a case-study proposing CAM16 as an alternative to the commonly used HSB & HSL pickers (endemic in most graphics software). For vibrating and vanishing boundaries, Albers states colors must be equally light but from differing hues, a task impossible to execute in HSB & HSL. Albers' terminology is catalogued, identifying synonymous CIE definitions that quantify lightness. Albers' examples of vibrating and vanishing boundaries validates the translation. CAM16 shows the ability to create vibrating and vanishing boundaries without manual color picking. Until CAM16 tools are introduced, the author encourages educators to address the confusion HSB & HSL pose.

1. INTRODUCTION

CAM16, a color appearance model (CAM), is more compatible with Josef Albers' *Interaction of Color* than industry standard color pickers HSB & HSL. His most difficult exercises, vibrating and vanishing boundaries, require equal lightness: an attribute poorly described in HSB & HSL, but accurately quantified in CAM16 (Li et al. 2017).

The majority of color pickers are mainly HSB. CIELChab pickers are rare (Gimp 2024); if including alternatives, most common software include only CIELab (Adobe 2024). HSB & HSL show perceptually vague attributes adjacent to accepted terms describing color appearance, such as "brightness" and "lightness". Its misleading metrics are generally regarded as a pain-point of the digital graphic workflow (Abeln 2011). Although HSB (Hue, Saturation, Brightness) and HSL (Hue, Saturation, Lightness) are different systems, they are analogous interpretations of identical colors. Specific instances of the maximally chromatic choice within a single hue in the systems are "apex colors". For example, HSB coordinates (H = 0°, S = 100%, B = 100%) and HSL coordinates (H = 0°, S = 100 %, L = 50%) identify the same apex red (#FF0000). With numerically identical B and L values, actually perceived lightness widely vary (O'Leary 2022). In most digital interfaces, they are usually the only attributes of "brightness" or "lightness" readily available.

2. METHOD

2.1 Translating Albers' Terminology

In writing that "Munsell defines value as the lightness of a color . . . we use 'light intensity' instead as a self-explanatory term" (Albers 2013: 73), Albers definitively equates his "light intensity" to Munsell's "value," an analogue of CIE's "lightness"(Kuehni 2001). In further explanations of "light intensity," Albers, writes that "these pictures consist of grey shades of the finest gradations between the poles of black and white," (Albers 2013: 12) confirming that when Albers writes of "light intensity" he is really refering to "lightness" as defined by the CIE (CIE 2020).

Vibrating and vanishing boundaries require what Albers calls equality in "light intensity," so CIE lightness—HSB & HSL's weakness. Albers admits this is "challenging," (Albers 2013: 62) especially when choosing colors from different hues (Albers 2013: 12).

2.2 Sample Measurement and Calculations

To ensure the integrity of deducing Albers' intent, measurements were taken of a pristine copy of the first edition of *Interaction of Color* published in 1964, from the Alfred and Blanche Knopf Library archived by the Harry Ransom Center at The University of Texas at Austin (Albers 1964). In his book, vibrating boundaries are shown in 3 examples: 2 in plate XXII-1 and 1 in plate XXII-2; vanishing boundaries are shown across 3 examples: plates XXIII-1, XXIII-2, and XXIII-3.

The flat surfaces were measured by a Nix Spectro L, in measurement mode M2 (Nix Color Sensor). The orange & blue (with concentric circles) example in plate XXII-1 was omitted from study due to the instrument's inability to accurately measure the thin blue lines, so only the right page (blue & red checkers) of plate XXII-1 was considered, along with plates XXII-2, XXIII-1, XXIII-2, and XXIII-3, totalling 5 exercises analyzed.

XYZ tristimulus values were calculated under D65 with the 1931 2° standard observer. Tristimulus values were converted to the sRGB space, yielding HSB & HSL values. The IEC's definition for the assumed viewing conditions for sRGB was used for the CAM16 & CIECAM02 calculations (IEC 1999), with static parameters: standard ambient illumination of 80 cd/m^2, adapting field luminance 20%, illuminant white point of D65, surround parameter "average," and discounting the illuminant (Colour Documentation 2024). CIELab values were calculated under D65.

2.3 Reverse Engineering: Interpreting Albers' Plates

The lightness values of the surface color pairs were compared in various CAMs. The chosen systems and appearance correlates which this paper refers to as L were CIELab's $L*$, CAM16's J, CIECAM02's J, HSB's B, and HSL's L. By assessing CIELab's $L*$, Google's HCT is also assessed, as its T "tone" is derived from $L*$ (O'Leary 2022).

The lightness value of one color L_1 and L_2 were subtracted with formula $\Delta L = |L_1 - L_2|$ The ΔL value indicates the discrepancy of the system's lightness difference from Albers' assertion of equivalence, with perfect agreement being $\Delta L = 0$. The higher the ΔL, the higher the disagreement. Due to the nature of the data evaluated, an equality of values, conventionally indicative of non-relation, really indicates significant agreement and relation. H_0 states $\Delta L > 0$, no relation to Albers, with alternative hypothesis H_a stating $\Delta L = 0$, perfect relation to Albers. Paired one-tailed two-sample t-tests evaluate significance.

2.4 Testing CAM Performance: Duo-Tone Vibrating Boundaries

Albers' instructions were put into practice using 6 background colors chosen (in HSB & HSL, H = 0°, 60°, 120°, 180°, 240°, and 300°). With the background color being named sample 1, the vibrating test foreground color (2) was calculated by having equal lightnesses $L_1 = L_2$, hues diametrically opposite for high hue contrast, $h_1 + 180° = h_2$, and chroma (or saturation in HSB & HSL) the maximum possible for that hue & lightness pair within the sRGB gamut. CIELab calculations were performed in CIELChab to yield hue & chroma.

3. RESULTS AND DISCUSSION

3.1 Reverse Engineering: Interpreting Albers' Plates

With null and alternative hypotheses H_0: $\Delta L > 0$, H_a: $\Delta L = 0$, and significance threshold $a = 0.01$, the data indicate CAM16 with $p = 0.0099$ (Table 2) as agreeing with Albers' claim of equivalent lightness the most. The greatest limitation of this test is the small sample size of 5 plates.

Table 1. Calculated lightness differences, $\Delta L = |L_1 - L_2|$, of measurements per CAM.

Plate	HSB (*B*)	HSL (*L*)	CAM16 (*J*)	CIECAM02 (*J*)	CIELab (*L**)	Albers' Assertion
XXII-1	2.64	8.56	1.31	0.48	3.44	0.00
XXII-2	12.85	35.39	2.15	1.41	0.10	0.00
XXIII-1	5.40	8.04	2.19	2.07	1.43	0.00
XXIII-2	5.24	3.28	0.37	0.26	0.24	0.00
XXIII-3	3.32	2.60	0.80	0.73	0.19	0.00

*Table 2. Paired one-tailed two-sample T-test of H_0: $\Delta L > 0$, H_a: $\Delta L = 0$, threshold for significance a = 0.01, significant values = ***.*

Statistic	HSB (*B*)	HSL (*L*)	CAM16 (*J*) ***	CIECAM02 (*J*)	CIELab (*L**)
Mean	5.89	11.58	1.36	0.99	1.08
P value	0.0159	0.0647	0.0099***	0.0204	0.0830

3.2 Evaluating CAM Performance: Duo-Tone Vibrating Boundaries

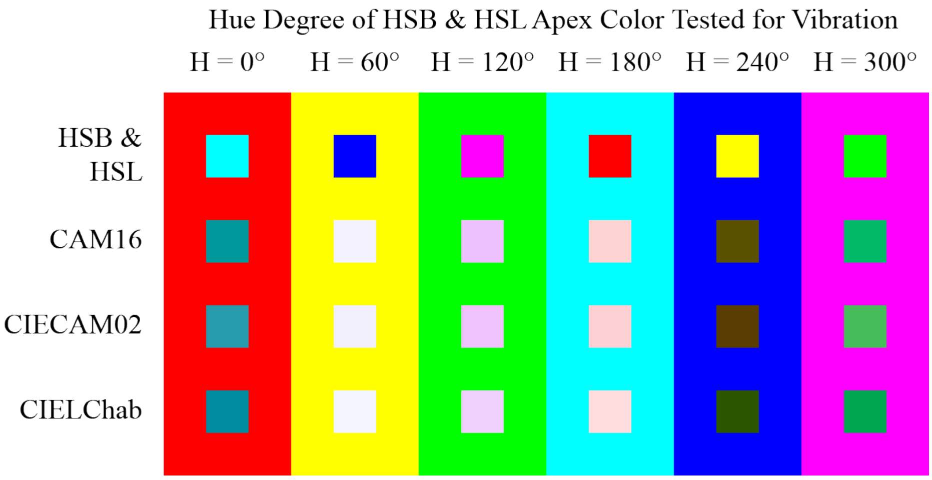

Figure 1: Various CAMs' calculated vibrating boundaries for multiple HSB apex colors.

In following Albers' instructions on producing vibrating boundaries, HSB & HSL perfomed poorly in each tested case (see Figure 1). CAM16 reliably produced vibrating boundaries without manual adjustment, proving forwards compatibilty with Albers.

4. CONCLUSIONS

This paper does not deal with the specifics of how a new tool would be implemented in a workflow, but is the necessary precursor of that dialogue. It proves CAM16 and similar models integrate tightly with the one of the artistic canon's most celebrated authoritative texts, *Interaction of Color* (Albers 1964). Together, the formerly dichotomous fields and perspectives mutually validate each other.

To the educator: remain teachable. When more robust tools become available, be open-minded to learning them, to begin teaching them. Continue to emphasize and re-emphasize the importance of sharpening skills of perception and color discernment, especially in light of HSB & HSL's limitations and misinformation.

CAM16 demonstrates the novel ability to automatically, rapidly, and reliably execute Albers' most challenging and labor intensive maneuvers: vibrating and vanishing boundaries. The core principle of authentically prioritizing perception transcends the differing jargon of the seemingly contrasting artistic and scientific disciplines.

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