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Color adjustment of brand logos for dark mode display

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Abstract

We investigated how to optimally adjust brand logo colors for dark mode displays without compromising their original color identity. Through analyzing manual color adjustments of logos placed on black backgrounds (N=31), we figured out that designers tend to light up the dark-colored logo, while pale down the colors of bright logo. A tendency similar to that of their adjustments converging in a specific direction was obtained, so we derived a surface model that represents the direction in which original colors tend to shift. This model incorporates the L^*, C^*, and h^* attributes to guide the computational adjustment process. This study offers a structured method for adapting logo colors to contemporary display contexts, effectively linking algorithmic solutions with design intuition.

Introduction

Dark mode is a user interface (UI) style that displays light-colored text and elements on a dark background [1]. It originally introduced to reduce eye strain in low-light environments [2], and now widely adopted across platforms due to both its functional benefits and aesthetic appeal [3].

While dark mode offers visual comfort and clarity, most existing research has concentrated on text readability, examining how contrast between background and text influences visual performance [4]. However, the visual behavior of non-textual elements such as icons, buttons, and especially brand logos remains underexplored. As these elements typically rely on precise color schemes, insufficient consideration of their appearance in dark mode may result in perceptual inconsistencies or design distortions.

Previous studies on color science proved that the color perception is strongly influenced by background color [5]. Thus, applying a logo designed for a white background directly onto a black interface can lead to perceptual shifts in brightness, hue, and saturation. These changes may undermine the original design intent and affect user perception of brand identity. Nevertheless, existing dark mode design guidelines primarily focus on ensuring sufficient contrast, which can lead to substantial perceptual differences when directly applied to brand logos [6].

Since logo colors plays important role in brand recognition and memorability, unintended color shifts in dark mode are more than just aesthetic issues, but directly impact branding effectiveness [7]. Therefore, to support consistent brand communication in evolving display environments, more nuanced design strategies that preserve both visual harmony and the integrity of brand colors when adapting to dark mode should be developed.

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The logo color adjustment process in dark mode was guided by three key principles: brand constancy, visibility, and visual comfort. **Brand constancy** ensures that a logo’s perceived color in dark mode aligns with its original appearance in light mode, preserving brand identity. **Visibility** focuses on maintaining sufficient contrast between the logo and the dark background, as dark-colored logos may otherwise become indistinct and reduce brand recognition. Finally, **visual comfort** addresses the viewer's perceptual response, as overly bright or saturated logos can cause discomfort in dark environments, disrupting the overall user experience. These three factors highlight the importance of a balanced and perceptually aware approach to logo adaptation in dark mode interfaces.

Color and Design of the Logo Stimuli

Color Selection

To cover a broad range of hues and tones, we constructed a color palette consisting of 18 colors. It included eight chromatic hues: red, orange, yellow, green, cyan, blue, purple, and pink, along with gray. Each chromatic color was paired with a darker shade. Detailed specifications are presented in Table 1.

Logo Stimuli Generation

To reduce potential bias from participants' prior familiarity with existing brands, we generated abstract brand names using ChatGPT 4.0 and designed corresponding logo shapes through Wix’s free logo-making tool. These logos were intentionally created to avoid associations with known objects or color identities. A total of 18 abstract logos were used in the initial color adjustment experiment, which led to the development of a predictive model for dark mode adaptation. Figure 2 shows the logo stimuli utilized in our study.

Table 1: Details of Stimuli Logo Colors

Color	H	S	V	L^*	a^*	b^*
Red	0	100	100	50.5	77.0	64.6
Orange	30	100	100	67.1	42.8	38.1
Yellow	57	100	95	89.6	-14.9	88.5
Green	120	100	90	79.6	-79.5	76.7
Cyan	185	100	95	81.1	-37.3	-22.4
Blue	255	100	95	37.4	55.4	-92.1
Purple	270	100	95	38.7	79.9	-89.7
Pink	310	100	95	55.2	89.2	-39.2
Gray	0	0	70	72.9	0.0	0.0
Dark Red	0	100	50	25.5	48.1	38.1
Dark Orange	30	100	50	34.5	24.0	44.8
Dark Yellow	60	100	50	51.9	-12.9	56.7
Dark Green	120	100	50	46.2	-51.7	49.9
Dark Cyan	180	100	50	48.3	-28.8	-8.5
Dark Blue	255	100	50	18.3	31.7	-55.8
Dark Purple	270	100	50	18.6	50.2	-55.2
Dark Pink	310	100	50	28.5	55.7	-24.6
Dark Gray	0	0	40	43.2	0.0	0.0

Figure 1. *18 logo stimuli used in this study*

Color Adjustment Experiment

Procedure

The experiment was conducted in a dark environment below 1 lx to minimize external lighting and reflections. Participants were given approximately five minutes for visual adaptation prior to the task. The monitor used in the experiment had its automatic brightness adjustment enabled, but its brightness was fixed at 40% of the maximum. A spectroradiometer (CM2000) confirmed the average luminance of a full white screen as 49.26 cd/m², a level deemed appropriate for visual comfort in previous studies [8]. The monitor's white balance was set to D65 and remained unchanged throughout.

Participants performed the color adjustment task using Figma's dark mode interface, which supports intuitive color manipulation through the HSV (Hue, Saturation, Value) model, which widely used in graphic design tools as shown in Figure 3. We used the HSV color model as implemented in Figma, which follows the CSS Color Module Level 4 standard. During the task, each logo stimulus was presented as a pair in the Figma workspace, one on a white background representing the original light mode version and the other on a black background for adjustment in dark mode. Participants were instructed to modify the dark mode logo color to match the perceived color identity of the original, while improving both visibility and visual comfort under dark conditions. Logo stimuli presented in Figure 2a were used in this experiment.

A total of 31 students majoring in design (19 female, 12 male) took part in the color adjustment experiment. The participants had a mean age of 24.32 years (SD = 2.62) and all reported normal color vision. As the experiment was conducted using the Figma platform, prior familiarity with the tool was required.

Result

To reflect human color perception, the collected logo colors were converted into the CIELAB color space. For each logo, we then computed the mean L^*, a^*, and b^* values of the adjusted colors provided by participants, in order to derive appropriate color representations for dark mode. Table 2 presents the average and standard deviation of the adjusted logo color CIELAB values.

Based on the color adjustments, we analyzed changes in color attributes to inform the development of a dark mode color adjustment model. Bright colors were typically darkened, while dark colors were brightened, suggesting that perceptual adaptation is needed to maintain visibility and brand identity in dark mode.

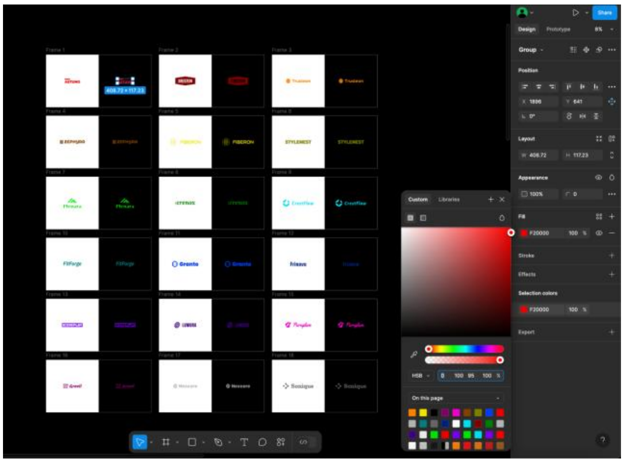

Figure 3. *The captured monitor provided to participants for the color adjustment experiment*

In terms of lightness (L^*), brighter colors in the palette showed a noticeable decrease, whereas darker colors increased in L^*, with the degree of adjustment varying by hue. Chroma (C^*) also showed a clear trend, that colors with higher initial chroma values underwent greater reductions, while those with lower chroma remained relatively stable. Hue (h^*) remained mostly unchanged across the adjustments, with the exception of red and blue. These hues exhibited slight shifts in hue angle, consistent with prior findings, who demonstrated that perceptual consistency often requires hue angle adjustments as chroma varies.

Table 2: Mean (standard deviation) of the adjusted color value

Color	L^*	a^*	b^*
Red	43.0 (7.6)	60.8 (7.5)	43.4 (9.9)
Orange	58.4 (8.1)	32.2 (7.6)	59.5 (8.9)
Yellow	76.9 (11.0)	-12.1 (1.8)	64.2 (12.0)
Green	68.7 (11.3)	-61.5 (9.4)	55.8 (9.7)
Cyan	69.8 (8.7)	-30.1 (4.6)	-17.0 (3.8)
Blue	38.0 (11.0)	36.3 (11.5)	-70.6 (11.6)
Purple	37.5 (8.1)	59.2 (11.7)	-66.9 (16.7)
Pink	46.2 (9.0)	65.7 (12.6)	-31.3 (5.5)
Gray	64.0 (12.2)	0.4 (1.6)	0.3 (0.9)
Dark Red	30.5 (10.0)	37.2 (12.4)	26.4 (11.3)
Dark Orange	43.8 (12.5)	19.4 (8.1)	41.2 (12.0)
Dark Yellow	60.1 (9.9)	-14.0 (2.5)	57.0 (11.1)
Dark Green	52.9 (11.6)	-49.6 (10.9)	45.5 (12.4)
Dark Cyan	61.5 (13.8)	-31.3 (6.6)	-8.5 (3.8)
Dark Blue	32.9 (18.9)	36.4 (11.5)	-70.6 (11.6)
Dark Purple	32.8 (16.2)	49.4 (14.4)	-56.5 (16.7)
Dark Pink	35.7 (13.6)	46.5 (12.6)	-22.8 (7.8)
Dark Gray	62.4 (15.0)	0.4 (1.9)	0.5 (1.4)

These findings offer valuable insights into how different colors converge within color space, informing the development of a model that systematically adjusts colors for dark mode applications.

Building Adjustment Model for Dark Mode

To model how logo colors should be adjusted for dark mode, we defined a model to find the appropriate logo color for dark mode using convergence area in CIELAB space, which is an irregular surface where adjusted colors tend to settle, through following steps.

Defining and smoothing the convergence surface: Participants' adjustments revealed that bright colors were darkened and dark colors were brightened, indicating convergence toward a specific layer in color space. Using midpoint calculations for color pairs and Gaussian-based Kriging interpolation, we generated a smooth convergence surface in CIELAB space. This method was selected for its stability and smoothness, making it suitable for modeling perceptual color transitions. Figure 2 shows the form of convergence surface.

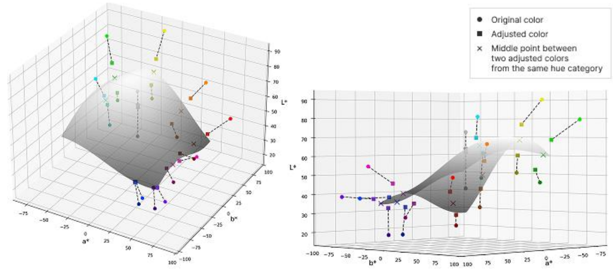

Figure 2. Convergence surface for color adjustment

Computing Relative Position to the Curve: To understand how each color relates to this surface, we projected the original color and its adjustment vector onto the L^*-C^* plane. Two displacement measures were calculated:

- d_{norm}: perpendicular distance to the curve (above/below the surface)
- d_{curve}: tangential distance along the curve (closer/farther from L^*)

The adjustment vector was decomposed into orthogonal components ($d_{\perp}^*$, $d_{\parallel}^*$) to describe the direction and magnitude of adjustment relative to the surface. Figure 3 shows the decomposition progress.

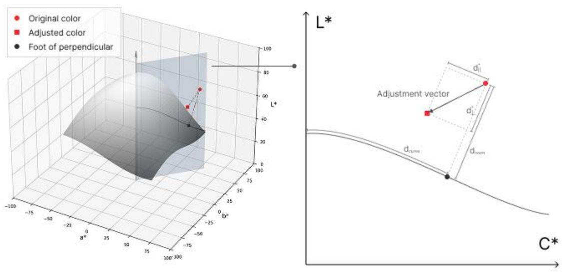

Figure 3. Computing relative position of adjustment vector and original color

Deriving Changes in Chroma and Lightness: Using the decomposed values, we performed quadratic regression to predict the necessary lightness and chroma changes. The model estimates the adjusted color position by applying the computed $d_{\perp}^*$ and $d_{\parallel}^*$, allowing for precise generation of new logo colors for dark mode.

Reference-Based Hue Correction via Interpolation: To apply hue correction, the closest reference colors in the LUT were selected based on chroma segment and hue proximity. We then used inverse distance weighted (IDW) interpolation between the reference hues to calculate the required hue shift for the adjusted color. This ensured that perceptual fidelity was maintained, especially for high-saturation reds and blues. Figure 4 shows the process of hue correction.

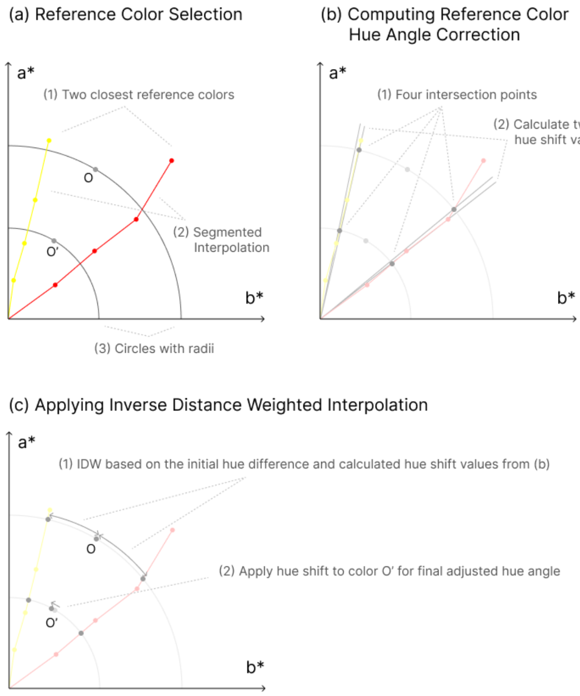

Figure 4. Hue angle correction process for adaptation

Together, these steps allowed the model to generate adjusted logo colors that maintain visual consistency, brand identity, and perceptual integrity when transitioning from light mode to dark mode.

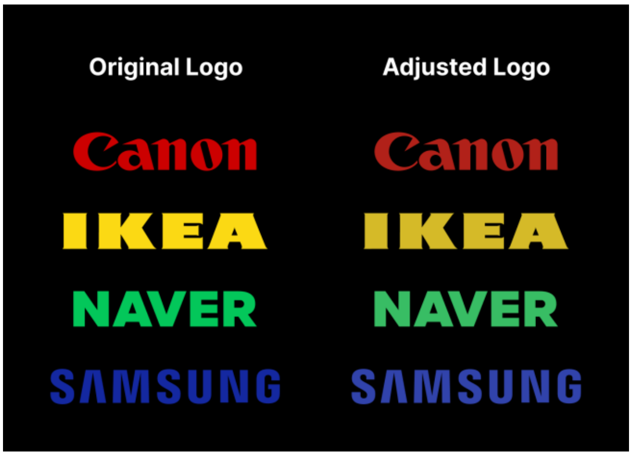

Figure 5. Examples of commercial logo with original and color adjusted with presented model

The derived color adjustment model is adaptable to brand logos regardless of their original hue, enabling consistent visual presentation in dark mode environments while preserving color identity. Figure 5 illustrates examples of commercial logos whose colors were adjusted using this model, demonstrating its practical applicability and effectiveness in real-world scenarios.

Discussion

This study proposes a systematic method for adapting brand logo colors to dark mode environments, addressing limitations in conventional design approaches that primarily emphasize contrast optimization. While traditional guidelines improve readability, they often overlook how background color affects the perception of chroma and hue, potentially distorting brand identity. To resolve this, the proposed model incorporates perceptual color tendencies, such as reduced saturation and hue shifts, informed by empirical user adjustments.

The adjustment experiment revealed that light and dark shades of a given hue tended to converge toward distinct midpoint regions in color space, rather than a universal neutral target. Notably, colors such as red and blue exhibited measurable hue angle shifts, consistent with established findings in color perception. The model reflects these trends by constructing a convergence surface in CIELAB space and guiding adjustments along both chroma and lightness axes, with additional hue corrections for colors prone to perceptual distortion.

However, the study has limitations that should be addressed in future work. First, the model was developed using a dataset of 18 color samples focused on high-chroma hues, limiting its precision for low-chroma inputs. Second, while the experiment assumed a uniform black background, actual dark mode interfaces often vary in tone and color, potentially affecting perceived color relationships. Thus, expanding the range of color samples, background types, and ambient lighting conditions will further improve the robustness and generalizability of the model.

Another limitation of the present study concerns individual variability. Because each participant adjusted the logo colors only once per stimulus, the dataset does not allow a direct comparison between intra-individual and inter-individual variability. As a result, the derived convergence surface was based solely on aggregated group data. While this approach provides a generalized model for dark mode color adjustment, it remains unclear whether the use of a single correction surface is justified when accounting for potential within-subject consistency. Future studies should incorporate repeated trials for each participant to quantify intra-individual variance and compare it with inter-individual differences. Such analysis would clarify whether the observed convergence tendencies are robust across individuals or primarily reflect group-level averaging, thereby strengthening the validity of the proposed model as a universal guideline for logo adaptation in dark mode environments.

From a practical perspective, the proposed model can be readily implemented in contemporary user interfaces. Major platformsm already provide system-level APIs that inform applications of the user's display mode preference [9]. By leveraging these flags, an application could automatically apply the adjustment model whenever dark mode is activated, ensuring perceptual consistency of brand logos across different environments. Nevertheless, our study assumed a uniform pure black background as the reference for dark mode. In practice, many interfaces employ dark gray or tinted backgrounds, which may interact differently with logo colors and alter perceived adjustments [10]. Future work should therefore extend the model to incorporate a wider range of background tones and chromatic variations, further enhancing its robustness and applicability in real-world settings.

Conclusion

This study presents a color adjustment model designed to maintain brand logo identity while improving visual comfort, visibility, and aesthetics in dark mode environments. Through a controlled color adjustment experiment, we identified key principles for modifying logo colors and used these insights to develop a predictive model. Based on these insights, we developed a color convergence surface and an adjustment model that captures how colors tend to shift during dark mode adaptation. The logo color adjustment examples generated using this model demonstrate its versatility and applicability across a wide range of color.

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