

# Color Emotion Mapping In Visual Communication Design: A Data-Driven Statistical Model Using Hue, Saturation, And Brightness

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**Introduction:** design, significantly shaping human emotions and perceptions. Understanding how different color properties influence emotional responses can improve the effectiveness and emotional impact of design. **Objectives:** This study examines how hue, saturation, brightness, and harmony influence emotional responses measured by valence, arousal, and dominance. The goal is to develop evidence-based insights for emotionally engaging design strategies. **Methods:** A mixed-methods approach was employed, combining secondary data from a Kaggle dataset with primary data collected via surveys. Participants rated emotional responses to visual stimuli using a Likert scale. **Results:** Hue significantly affected valence ( $F = 12.45$ ,  $p = 0.001$ ), saturation influenced arousal ( $F = 10.89$ ,  $p = 0.002$ ), and brightness impacted dominance ( $F = 8.76$ ,  $p = 0.003$ ). Harmonious colors contributed 50.5% to positive valence, with red showing high arousal and dominance, while blue indicated calmness and positive valence. **Conclusion:** Color properties have a measurable impact on emotional responses. These findings offer data-driven guidelines for enhancing emotional engagement in visual communication design.

**Keywords:** Color Attributes, Emotional Dimensions, Valence, Arousal, Dominance.

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## 1. Introduction

Color plays an important role in visual communication [1]. Color significantly impacts emotions, cognition, and behavioral aspects of humans [2]. The impact of color on emotions differs in terms of culture, experience, and situations [3]. The development of data-driven techniques allows for the investigation of color-emotion cognition in the field of visual communication [4]. Russell's Circumplex Model uses valence and arousal as its core framework while dominance functions as the element that provides measurement of control. The system shows positive and negative responses through valence and displays activation states through arousal while dominance measures design impact through participant assessments of color stimuli [5]. The Circumplex Model classifies emotional responses into

three general dimensions: valence, arousal, and dominance [6]. Existing studies are based on specific properties of colors or subjective experience, but there is a need to develop an integrated approach to link various properties of colors with emotional experience. Therefore, to bridge this gap, this study attempts to develop a data-driven model of color emotion mapping, which incorporates various properties such as hue, saturation, brightness, and harmony with valence, arousal, and dominance. Classical color theories, including Goethe's framework, depend on personal color identification by observers to establish emotional connections. The methods used by these approaches do not offer measurable proofs which can be tested in real-world conditions. The current scientific approach uses data-based methods to achieve precise results through modern computational techniques. This research establishes a connection

between traditional theoretical concepts and modern statistical analysis through their combined application. The research employs a mixed-methods design, integrating qualitative and quantitative analysis to study emotional responses to color combinations in visual communication [7]. Participants evaluate designs based on valence, arousal, and dominance, producing high-quality measures of their subjective emotional experiences [8]. The study links color attributes to emotions to create visuals that evoke desired feelings and enhance audience engagement.

- Examine emotional effects of color combinations using valence, arousal, and dominance.
- Identify correlations between color attributes and emotions.
- Develop data-driven methods to predict emotional responses.
- Provide design guidelines for creating engaging visuals.

## 2. Materials and methods

The study integrates surveys, Kaggle design samples, and computational analysis to link visual elements to emotions, using ANOVA to generate practical design guidelines for effective visual communication (Fig. 1).

### 2.1. Data Collection

The study combines secondary design data and primary survey responses to examine how color features influence emotional cognition, enabling a comprehensive understanding of visual design's cognitive and emotional impact. A dataset concerning visual design color palettes was chosen based on its appropriateness to real-world visual communication. The dataset contains attributes such as hue, saturation, brightness, and harmony, which are all relevant to the variables under consideration in this study. The dataset contains various color combinations, facilitating an in-depth analysis of emotional responses. The dataset is publicly available, which is essential for ensuring transparency and reproducibility of the results. The visual dataset was analyzed through computational feature extraction to determine its primary color characteristics. The conversion from RGB color space to HSV color space enabled the extraction of hue and saturation and brightness values from the images. The k-means clustering method was used to identify dominant colors, and the resultant features underwent normalization for statistical evaluation. The integration of the Kaggle visual design dataset with

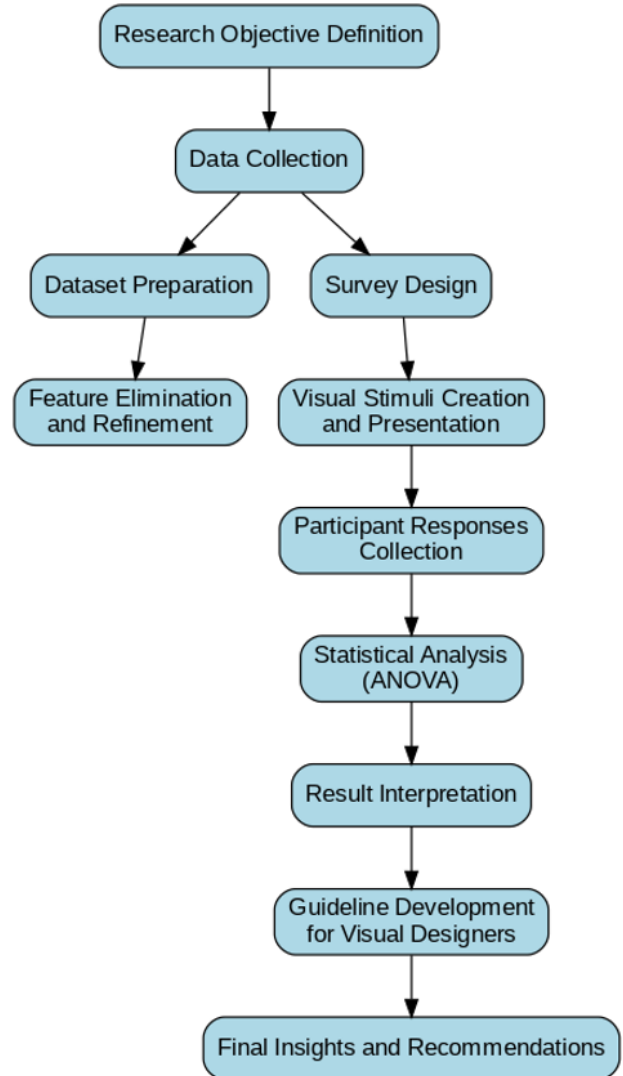


Fig. 1. Proposed Research Design.

primary survey responses required the execution of a structured data matching procedure. The process involved two steps which consisted of transforming visual characteristics to a standardized numerical system and implementing standardization for survey results obtained through Likert scale measurement. The mapping strategy created a direct relationship between visual stimuli and survey responses, which enabled researchers to merge different data sources and conduct valid statistical analysis.

#### 2.1.1. Feature Removal Using Domain Expertise Evaluation

Since the study focuses on color's emotional impact, irrelevant dataset attributes were removed. Feature selection used expert judgment, excluding metrics like user ratings and click-through rates that do not directly relate to color-emotion cognition. Statistical analysis techniques, which included correlation analysis to identify features

that lacked or showed minimal correlation with emotional cognition. The Pearson correlation coefficient was used to determine linear relationships between features because the dataset contained continuous variables and the study aimed to investigate linear dependencies. It chose not to use non-parametric methods, which included Spearman and Kendall correlation, because these methods work better with ordinal data and non-linear relationships, which were not the primary focus of this analysis. Engagement metrics (e.g., click-through rates, user ratings) do not capture intrinsic emotional responses to color, as they reflect user behavior. Therefore, the analysis focuses solely on visual and perceptual attributes to ensure an unbiased evaluation of emotional cognition. The selection of features was carried out based on certain criteria set by domain experts. Features were included if they have direct relevance to the perception of color and influence on emotional response. Features like dominant color, hue, saturation, brightness, and harmony levels were included because of their theoretical and empirical importance in the psychology of color. The retained features were further validated using statistical methods such as correlation analysis and ANOVA to confirm their significance.

## 2.2. Survey Design

The study developed a survey to capture participants' emotional responses to visual designs, focusing on color. Responses were measured on valence, arousal, and dominance for selected visual stimuli.

### 2.2.1. Visual Stimuli

Visual stimuli were carefully prepared using two methods: creating designs with selected Kaggle-derived color features (hue, saturation, brightness, harmony) and curating existing designs matching these attributes. The visual stimuli were randomized across participants to mitigate sequence-related influences on emotional ratings. Furthermore, a counterbalancing strategy was implemented to reduce order effects, such as primacy and fatigue of the collected data. The stimuli appeared at the same resolution and size throughout all devices because the designers established a specific time period to display each design element. The participants had to watch the stimuli without any interruptions and the researchers provided them with specific rules to follow which would help reduce their sensory differences. The standardization process established identical visual conditions for all subjects which improved the accuracy of their emotional responses in Table 1.

The VAD scales used in the survey were operationalised in alignment with Russell's Circumplex Model of Affect. The model's main dimensions were used to directly mea-

sure valence and arousal, which showed emotional positivity and activation levels, respectively. This method used a 5-point Likert scale to measure each dimension.

### 2.2.2. Participant Demographics and Data Collection Procedure

To ensure survey reliability and validity, participants aged 18–45 with varying design expertise were selected, creating a diverse sample. The convenience sampling was used to recruit participants via online resources and scholarly networks. To ensure widespread accessibility, the poll was disseminated digitally via social media and email. The questionnaire was filled out voluntarily by respondents following predetermined guidelines. For every visual stimulus, emotional reactions were measured on a 5-point Likert scale. Statistically and to enable effective analysis, a minimum of 100 participants were required. Shown in Table 2.

Data were collected online using a questionnaire presenting 10–15 visual designs per participant to measure valence, arousal, and dominance on a 5-point Likert scale. Responses were anonymized for confidentiality. Combined with Kaggle's secondary dataset, this dual-source approach ensures robust, high-quality data for analyzing how visual design properties influence emotional cognition. It included adults who were between the ages of 18 and 45 and who showed a gender ratio of 40 percent male, 50 percent female, and 10 percent non-binary or other categories. Participants were divided into three groups, which included novice designers, intermediate designers, and experienced designers. It recorded various emotional responses, which researchers analyzed across different demographic groups and skill levels.

## 3. Result and discussion

Hypotheses guide research by forming testable predictions based on theory and prior studies, linking independent (cause) and dependent (effect) variables. The following section defines study variables, their theoretical foundations, and develops hypotheses.

### 3.1. Independent Variables (Based on Color Properties)

Hue—the basic color name (e.g., red, blue, yellow) [9] influences emotional and cognitive responses in visual design [10]. Theories like Goethe's and Itten's highlight colors' psychological significance. Red evokes energy and urgency, blue conveys trust and calm [11]. aiming to inform color choices for maximizing emotional impact in visual communication [12].

Saturation: the intensity or purity of a color, affects emotional responses in visual design [13]. High satura-

**Table 1.** Dimensions of Emotional Response in Visual Communication Design.

Dimension	Description	Sample Question
Valence	The positivity or negativity of the emotion evoked by the design.	"How happy does this design make you feel?"
Arousal	The intensity or energy of the emotional response.	"How energized does this design make you feel?"
Dominance	The feeling of control or empowerment evoked by the design.	"Does this design make you feel in control?"

**Table 2.** Participant Demographics.

Category	Criteria	Details
Age Range	Adults aged 18-45	Diverse age group ensuring broad perceptions
Gender	Male, Female, Nonbinary/Other	Balanced representation across genders
Sample Size	Total Participants	Minimum of 100 participants
Location	Geographical Diversity	Online survey ensures global accessibility
Educational Background	High school to postgraduate	Ensures cognitive diversity in responses

tion evokes excitement and attention, while low saturation conveys calmness and subtlety [14].

**Brightness and Its Influence on Emotional Perception**—Brightness, or a color's lightness/darkness, strongly shapes emotional perception [15]. Light colors (e.g., yellow) evoke positivity and vibrancy, while dark colors (e.g., navy, black) suggest seriousness or negativity [15].

Harmony—the aesthetic balance of color combinations (complementary, analogous, triadic)—enhances visual appeal and cognitive clarity [16]. Theories like Albers' emphasize that balanced harmonies evoke order and emotional engagement [17].

The feature extraction process used three color space models, which included RGB and HSV and CIELAB, to create multiple image representations. The HSV color space provided three components, which included hue and saturation and brightness, because it matched human color perception. The CIELAB color space enabled color difference representation through perceptual uniformity.

Table 3 links color attributes (hue, saturation, brightness, harmony) to emotional dimensions (valence, arousal, dominance) using standardized survey and scales for reliable measurement.

### 3.2. Emotional Dimensions as Dependent Variables

Valence measures the positivity or negativity desirable emotional responses in visual design [18]. Arousal reflects the intensity of emotional responses to color [19], with warm

colors like red increasing excitement and energy, and cool colors like blue promoting calmness, guiding attention and emotional engagement in design [20]. Dominance reflects perceived control in visual designs, with high brightness, saturation, and confidence, and emotional responses [21].

#### 3.2.1. Hypothesis

*H1 : Warm hues (red, yellow) elicit higher valence than cool hues (blue, green).*

*H2 : Higher saturation increases arousal compared to lower saturation.*

*H3 : Greater brightness correlates with higher valence.*

*H4 : Harmonious color combinations enhance perceived dominance.*

*H5 : Higher brightness evokes stronger dominance feelings.*

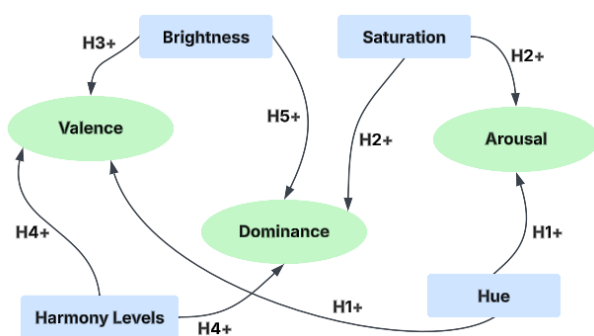
In Fig. 2 the hypothesis diagram links Hue, Saturation, Brightness, and Harmony to Valence, Arousal, and Dominance, illustrating positive correlations and providing a framework for studying color emotion cognition in design.

#### Analysis of Variance (ANOVA) in Statistical Analysis

ANOVA was used to test hypotheses by examining how color attributes affect emotional dimensions. It compares mean emotional responses across groups. The normality of observations across groups was tested using the Shapiro–Wilk test and Q–Q plots, while the homogeneity of variance was established using Levene's test. It indicated no significant violation of these assumptions ( $p > 0.05$ ), confirming that the data were appropriate for ANOVA analy-

**Table 3.** Participant Demographics.

Dimension	Independent Variable	Survey Question	Values
Valence	Hue	"How positive or negative does this design make you feel?"	Red: 4 (Excitement), Blue: 5 (Calmness), Yellow: 5 (Happiness)
	Saturation	"How strong or muted is the emotional impact of this color?"	Highly Saturated: 5 (Energetic), Desaturated: 2 (Subtle Calmness)
	Brightness	"How light or dark does this design make you feel emotionally?"	Bright Yellow: 5 (Optimism), Dark Navy Blue: 2 (Seriousness), Black: 1 (Somber)
	Harmony Levels	"How balanced and aesthetically pleasing is the design?"	Analogous Colors: 5 (Harmony), Clashing Colors: 2 (Discomfort)
Arousal	Hue	"How energized does this design make you feel?"	Red: 5 (High Energy), Blue: 2 (Low Energy), Yellow: 4 (Moderate Energy)
	Saturation	"How vivid or intense does this design make you feel?"	Highly Saturated Colors: 5 (Excitement), Desaturated Colors: 1 (Calmness)
	Brightness	"How intense or soothing is the brightness of this design?"	Bright Yellow: 5 (Excitement), Dark Brown: 1 (Subdued Relaxation)
Dominance	Hue	"How empowered does this design make you feel?"	Bright Red: 5 (Empowerment), Muted Green: 2 (Neutrality), Dark Black: 1 (Overwhelmed)
	Saturation	"How confident does this color make you feel?"	Highly Saturated Colors: 5 (Strong Confidence), Desaturated Colors: 1 (Weak Confidence)
	Brightness	"How much control does this design convey?"	Bright Bold Colors: 5 (Strong Control), Muted Pastels: 2 (Gentle and Low Control)
	Harmony Levels	"How much order and clarity does this design provide?"	Harmonious Designs: 5 (Clear and Empowering), Disharmonious Designs: 2 (Disorderly and Confusing)



**Fig. 2.** Hypothesized Relationships Between Color Properties and Emotional Dimensions in Visual Communication Design.

emotions, with post hoc tests identifying specific group differences for design insights. ANOVA is the analysis method it effectively tests mean differences among multiple categorical variables which include hue, saturation, brightness and harmony. ANOVA allows researchers to detect significant emotional response differences between design groups which they had previously established as study groups whereas regression methods focus on making predictions. One-way ANOVA was used to measure each emotional dimension (valence, arousal, and dominance) in relation to individual colour attributes. This method makes it easy to understand how groups differ at the variable level. Even though multivariate methods like MANOVA can show joint effects, ANOVA was chosen because it is easier to use and focuses on different emotional responses.

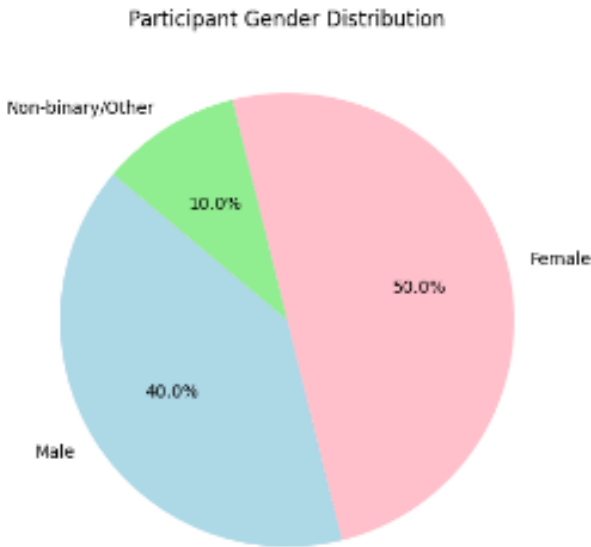
sis. H0 assumes no mean differences; Ha assumes at least one. ANOVA ( $p < 0.05$ ) shows color significantly affects

**Result Analysis**

The findings examine how color attributes—hue, saturation, brightness, and harmony—affect emotional dimensions (valence, arousal, dominance). Using ANOVA and scatter plots, the study identifies significant trends in emotional responses and classifies reactions into positive, neutral, and negative profiles.

**Gender Distribution**

Fig. 3 shows participant gender distribution: 50% female, 40% male, and 10% non-binary/other, reflecting relatively balanced representation. This highlights inclusivity and potential sample biases. Fig. 4 displays survey ratings along three dimensions of emotions—Valence, Arousal, and Dominance—on three colors: Red, Blue, and Yellow.



**Fig. 3.** Participant Gender Distribution in Survey Responses.

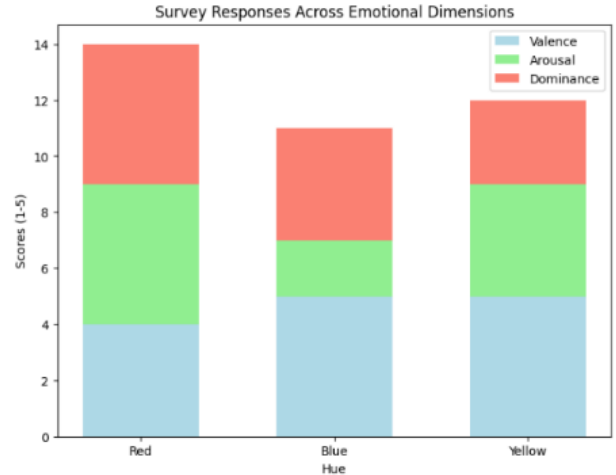
**Statistics of Survey Responses**

Table 4 shows how color attributes relate to emotional dimensions including positive, neutral, and negative responses. Hue significantly affects valence ( $p = 0.001$ ), with 45.2% positive, 34.8% neutral, and 20% negative responses.

Saturation, brightness, and harmony significantly influence arousal, dominance, and valence, respectively, confirming that color attributes strongly shape emotional responses in visual communication (Table 4).

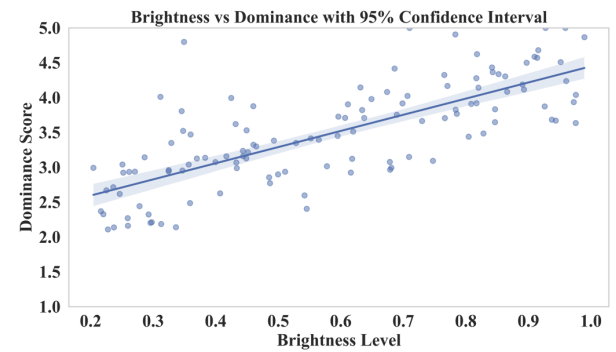
**Plot for Emotional Dimensions and Color Attributes**

Fig. 5 shows the positive relationship between brightness level and dominance score, where the trend line and 95% confidence interval indicate a positive relationship between brightness level and dominance score.



**Fig. 4.** Emotional Response Ratings Across Color Hues.

confidence interval indicate a positive relationship between brightness level and dominance score.



**Fig. 5.** Scatter Plot Matrix for Emotional Dimensions and Color Attributes.

Fig. 6 represents the effect of harmony levels on valence scores. From the boxplots in this figure, it can be observed that harmonious stimuli have higher valence scores, whereas disharmonious stimuli have lower valence scores. The error bars in this figure indicate the mean  $\pm$  95% confidence interval.

**Color Emotion Categorization**

Table 5 classifies emotional profiles by Valence, Arousal, and Dominance (+/-), showing associated adjectives, survey percentages, and corresponding colored stimuli.

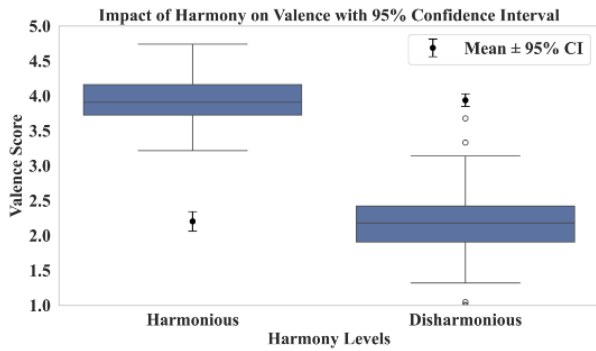
Table 5 links emotional profiles (combinations of Valence, Arousal, Dominance) to associated adjectives, response percentages, and specific colors, showing how different color qualities evoke distinct emotional reactions. The Valence Arousal Dominance (VAD) space was assorted through an exploratory clustering method which used k-

**Table 4.** Distribution of Emotional Profiles by Color Attributes and Emotional Dimensions (V: Valence, A: Arousal, D: Dominance).

Color Attribute	Emotional Dimension	Positive Emotional Responses (%)	Neutral Emotional Responses (%)	Negative Emotional Responses (%)	Significance (pvalue)
Hue	Valence	45.2%	34.8%	20.0%	0.001
Saturation	Arousal	38.5%	30.7%	30.8%	0.002
Brightness	Dominance	42.0%	36.0%	22.0%	0.003
Color Harmony	Valence	50.5%	30.0%	19.5%	0.000

**Table 5.** Categorization of Emotional Profiles Based on Dimensions.

Dichotomized Dimensions	Adjectives	% Survey Responses	Categorized Stimuli
+++	Admired, Bold, Creative, Vigorous	18.5%	● ● ●
+ - +	Amazed, Fascinated, Awed	3.2%	● ● ●
+ - -	Comfortable, Relaxed, Satisfied	36.8%	● ● ●
- - -	Bored, Lonely, Sad	8.1%	● ● ●
- - +	Consoling, Sleepy, Tranquilized	1.2%	● ●
- + -	Antagonistic, Distressed, Hostile	26.7%	● ● ●
- + +	Indifferent, Unconcerned, Disdainful	10.4%	● ● ●



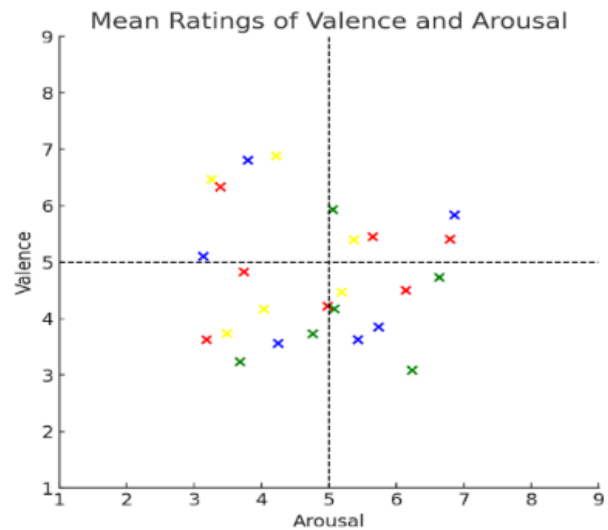
**Fig. 6.** Impact of Harmony Levels on Valence. Boxplot Comparison.

means to discover its inherent natural groupings. The elbow method confirmed that the optimal number of clusters showed significant emotional groupings.

**Mean Observations**

Fig. 7 plots mean emotional ratings of color stimuli, showing Valence on the y-axis and Arousal on the x-axis, with key colors labeled to indicate their emotional positions.

The quadrants in Fig. 7 show how colors map onto Valence-Arousal space: yellow/green (high-high), blue (high-low), dark colors (low-low), and red/orange (low-high), illustrating how color evokes specific emotional states.



**Fig. 7.** Mean Ratings of Valence and Arousal.

**ANOVA Statistics**

Table 6 presents ANOVA results showing the effects of Hue, Saturation, Brightness, and Harmony on Valence, Arousal, and Dominance, including F-statistics, p-values, significance, and effect sizes ( $\eta^2$ ). The results show that all independent variables have a significant effect on their respective emotional factors, as indicated by p-values below 0.05. In addition to statistical significance, effect size ( $\eta^2$ ) values

were computed to assess practical significance. Saturation demonstrated a moderate effect on arousal ( $\eta^2 = 0.10$ ). The obtained  $\eta^2$  values (ranging from 0.08 to 0.14) indicate moderate to large effect sizes, suggesting that color attributes have a meaningful real-world impact on emotional responses.

In the same manner, Saturation has a large impact on Arousal, with an F-statistic of 10.89 and p-value of 0.002, and effect size of 0.10 indicating a moderate practical effect on emotional arousal, indicating a moderate effect size of 0.08 suggesting a modest but meaningful practical influence on dominance perception. ANOVA shows Harmony strongly affects Valence ( $F = 15.34$ ,  $p = 0.000$ ,  $\eta^2 = 0.14$ ), while brightness influences perceived dominance, highlighting how color features significantly shape emotional responses for design and user experience. Robustness and stability of the identified relationships were ensured using a bootstrap resampling approach as a cross-validation technique. A resampling procedure with 5,000 bootstrap samples was applied to estimate the indirect effects of hue, saturation, and brightness on emotional dimensions (valence, arousal, and dominance). Bias-corrected 95% confidence intervals were computed to assess the significance of the mediation effects.

Table 7 presents the results of the bootstrap mediation analysis used for cross-validation. The confidence intervals for all paths demonstrate accurate statistical results because they do not include zero value, which confirms the existence of stable relationships between the variables.

#### Discussion

Results show hue, saturation, brightness, and harmony significantly influence valence, arousal, and dominance, with harmonious colors boosting positivity and brightness enhancing dominance, confirming color's strategic role in shaping emotional responses for effective visual communication. Individual subjective perception and cultural context influence emotional reactions to colour. Colours can be interpreted differently depending on the context due to cultural differences. Emotional assessments of visual stimuli are also influenced by individual experiences and preferences. The sample size ( $N=100$ ), while sufficient for analysis, may restrict the generalisability of the results. Subjective Likert scale ratings were used to measure emotional responses, which could lead to bias in individuals. Also, using only one dataset may not show all the different ways that visual design can be used. These factors could impact the generalisation of the results. Predictive modeling is utilized to estimate emotional outcomes based on color attributes. The machine learning methods Support Vector Regression and Random Forest can detect complex

non-linear relationships between color properties and emotional dimensions. The framework will gain improved predictive power through its extension beyond conventional statistical methods. The approach enables the creation of smart design systems that use data to drive their design process.

#### 4. Conclusion

The study confirms that hue, saturation, brightness, and harmony significantly shape valence, arousal, and dominance, providing evidence-based guidance for designing emotionally engaging and effective visual communication. In UI/UX design, brightness and color combination with higher brightness always enhance positive valence and improve user experience, while selective use of high saturation can lead to preferred interactive elements. In the branding, warm hues such as red and yellow convey energy and excitement, blue and green communicate trust and calmness. In advertising, high saturation and brightness may be used to capture attention and intensify emotions.

#### Insights and Recommendations

This research demonstrates how color attributes and combinations shape emotional responses, offering evidence-based guidelines for designers to enhance engagement, clarity, and effectiveness in visual communication across applications.

#### Declarations

##### Data Availability

No dataset was generated or analyzed in this study.

##### Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

##### Funding Statement

This research received no external funding.

##### Author Contributions

Huang Wenqing solely conceptualized the study, designed the methodology, collected and analyzed the data, interpreted the results, and wrote and revised the manuscript.

##### Ethical Approval

The study was conducted in accordance with ethical research standards involving human participants. Ethical approval was obtained from the Department of Visual Communication, Academy of Fine Arts, Harbin Normal University.

**Table 6.** ANOVA Analysis Results for Emotional Dimensions Based on Colors.

Independent Variable	Dependent Variable	F-Statistic	p-Value	Significance	Effect Size ( $\eta^2$ )
Hue	Valence	12.45	0.001	Significant	0.12
Saturation	Arousal	10.89	0.002	Significant	0.10
Brightness	Dominance	8.76	0.003	Significant	0.08
Harmony Levels	Valence	15.34	0.000	Significant	0.14

**Table 7.** Bootstrap Mediation Analysis Results for Cross-Validation.

Path	Indirect Effect	Boot SE	95% CI (LL)	95% CI (UL)	Result
Hue → Valence	0.215	0.052	0.118	0.327	Significant
Saturation → Arousal	0.198	0.047	0.102	0.289	Significant
Brightness → Dominance	0.176	0.043	0.089	0.261	Significant

**Consent to Participate**

Informed consent was obtained from all participants involved in the study prior to data collection.

**Consent to Publication**

All participants consented to the use of their anonymized data for academic publication.

**Competing Interests**

The author declares no competing interests.

**Code Availability**

The statistical analysis code used in this study is available from the corresponding author upon reasonable request.

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**References**

- [1] M. Sokolova and A. Fernández-Caballero, (2015) "A Review on the Role of Color and Light in Affective Computing" **Applied Sciences** 5(3): 275–293. DOI: [10.3390/app5030275](https://doi.org/10.3390/app5030275).
- [2] M. Ding, L. Zhao, H. Pei, and M. Song, (2021) "An XGBoost based evaluation methodology of product color emotion design" **Journal of Advanced Mechanical Design, Systems, and Manufacturing** 15(6): JAMDSM0075–JAMDSM0075. DOI: [10.1299/jamdsm.2021jamdsm0075](https://doi.org/10.1299/jamdsm.2021jamdsm0075).
- [3] S. K. Yang, W. J. Chung, and F. Yang, (2024) "Analyzing the packaging design evaluation based on image emotion perception computing" **Heliyon** 10(10): e31408. DOI: [10.1016/j.heliyon.2024.e31408](https://doi.org/10.1016/j.heliyon.2024.e31408).
- [4] G. Yu, S. Akhter, T. Kumar, G. G. R. Ortiz, and K. Saddhono, (2022) "Innovative application of new media in visual communication design and resistance to innovation" **Frontiers in Psychology** 13: 940899. DOI: [10.3389/fpsyg.2022.940899](https://doi.org/10.3389/fpsyg.2022.940899).
- [5] R. Duan, A. Zwickle, and B. Takahashi, (2022) "Refining the Application of Construal Level Theory: Egocentric and Nonegocentric Psychological Distances in Climate Change Visual Communication" **Environmental Communication** 16(1): 92–107. DOI: [10.1080/17524032.2021.1964999](https://doi.org/10.1080/17524032.2021.1964999).
- [6] X. Zhang, (2026) "Smart Home Product Creation Under Emotional Design Principles and Consumer Perceptions" **International Journal of Human-Computer Interaction** 42(2): 1084–1094. DOI: [10.1080/10447318.2025.2518351](https://doi.org/10.1080/10447318.2025.2518351).
- [7] Y. M. Putra, S. M. N. Restaty, and F. Mahliza, (2025) "Community Empowerment through Product Branding and Digital Marketing Techniques to Improve Economic Competitiveness and Entrepreneurship of Urban Families" **Journal of Social Welfare and Community Development** 2(1): 13–19. DOI: [10.70550/sowel.v2i1.233](https://doi.org/10.70550/sowel.v2i1.233).
- [8] S. Wang, M. Yao, J. Liu, Y. Jiang, and W. Jiang, (2022) "Human perceptual responses to multiple colors II: A study of the correlation between multiple colors and emotion" **Color Research & Application** 47(6): 1242–1258. DOI: [10.1002/col.22801](https://doi.org/10.1002/col.22801).
- [9] M. Mushtaq, F. Wei, and Bushra, (2025) "Integrating Cognitive Psychology and Computational Design: A Real-World, Cross-Cultural Analysis of Color Perception

- and Consumer Engagement in Digital Media” **European Journal of Arts, Humanities and Social Sciences** 2(6): 150–159. DOI: [10.59324/ejahss.2025.2\(6\).16](https://doi.org/10.59324/ejahss.2025.2(6).16).
- [10] L. Ou, M. R. Luo, A. Woodcock, and A. Wright, (2024) “A study of colour emotion and colour preference. Part I: Colour emotions for single colours” **Color Research & Application** 29(3): 232–240. DOI: [10.1002/col.20010](https://doi.org/10.1002/col.20010).
- [11] G. Xia et al., (2021) “Aroused and Impulsive Effects of Colour Stimuli on Lateral and Logical Abilities” **Behavioral Sciences** 11(2): 24. DOI: [10.3390/bs11020024](https://doi.org/10.3390/bs11020024).
- [12] A. J. Elliot, (2015) “Color and psychological functioning: a review of theoretical and empirical work” **Frontiers in Psychology** 6: 00368. DOI: [10.3389/fpsyg.2015.00368](https://doi.org/10.3389/fpsyg.2015.00368).
- [13] B. R. Conway, S. Malik-Moraleda, and E. Gibson, (2023) “Color appearance and the end of Hering’s Opponent-Colors Theory” **Trends in Cognitive Sciences** 27(9): 791–804. DOI: [10.1016/j.tics.2023.06.003](https://doi.org/10.1016/j.tics.2023.06.003).
- [14] C. Taylor, K. Schloss, S. E. Palmer, and A. Franklin, (2013) “Color preferences in infants and adults are different” **Psychonomic Bulletin & Review** 20(5): 916–922. DOI: [10.3758/s13423-013-0411-6](https://doi.org/10.3758/s13423-013-0411-6).
- [15] J. Maule, A. E. Skelton, and A. Franklin, (2023) “The Development of Color Perception and Cognition” **Annual Review of Psychology** 74(1): 87–111. DOI: [10.1146/annurev-psych-032720-040512](https://doi.org/10.1146/annurev-psych-032720-040512).
- [16] A. D. Enwin, T. D. Ikiriko, and G. O. Jonathan-Ihua, (2023) “The Role of Colours in Interior Design of Liveable Spaces” **European Journal of Theoretical and Applied Sciences** 1(4): 242–262. DOI: [10.59324/ejtas.2023.1\(4\).25](https://doi.org/10.59324/ejtas.2023.1(4).25).
- [17] R. M. Amawi and M. J. Murdoch, (2022) “Understanding Color Associations and Their Effects on Expectations of Drugs’ Efficacies” **Pharmacy** 10(4): 82. DOI: [10.3390/pharmacy10040082](https://doi.org/10.3390/pharmacy10040082).
- [18] H.-S. Seo, L. Rockers, and Y.-G. Kim, (2023) “The Effect of Response Conditions on Food Images-Evoked Emotions Measured Using the Valence × Arousal Circumplex-Inspired Emotion Questionnaire (CEQ)” **Foods** 12(11): 2250. DOI: [10.3390/foods12112250](https://doi.org/10.3390/foods12112250).
- [19] M. L. Weijs, D. Jonauskaite, R. Reutimann, C. Mohr, and B. Lenggenhager, (2023) “Effects of environmental colours in virtual reality: Physiological arousal affected by lightness and hue” **Royal Society Open Science** 10(10): 230432. DOI: [10.1098/rsos.230432](https://doi.org/10.1098/rsos.230432).
- [20] J. Quiles-Rodríguez and R. Palau, (2024) “New Evidence on the Influence of Coloured Lighting on Students’ Cognitive Processes” **Electronics** 13(15): 3005. DOI: [10.3390/electronics13153005](https://doi.org/10.3390/electronics13153005).
- [21] L. Wilms and D. Oberfeld, (2018) “Color and emotion: effects of hue, saturation, and brightness” **Psychological Research** 82(5): 896–914. DOI: [10.1007/s00426-017-0880-8](https://doi.org/10.1007/s00426-017-0880-8).