Chromatic Resonance: Investigating the Effects of Dynamic Color Changes on Human Emotional Responses

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Abstract: This study investigates the impact of dynamic color changes on human emotional responses by exploring variations in color saturation and transition modes. Previous research has established that static colors evoke specific emotional associations; for example, red is linked with vitality and enthusiasm, blue with sadness and tranquility, and green with nature and freshness. To expand on this understanding, an experiment was designed utilizing the Berkeley Color Project 32 (BCP-32), where participants were grouped to observe three types of video stimuli: discrete high-saturation transitions between red and blue, continuous high-saturation transitions between yellow and violet, and continuous low-saturation transitions between the same colors. Following the viewing, participants completed a questionnaire to assess their emotional reactions. The findings indicate that while the mode of color transition—discrete or continuous—did not significantly alter emotional responses, changes in color saturation produced noticeable effects on participants' emotions. This suggests that the intensity of a color, rather than the manner of its change, plays a more pivotal role in influencing human emotional states.

Keywords: Visual perception, Psychology, Color-emotion.

1. Introduction

The influence of color on human emotions has been a topic of extensive investigation across various disciplines. It is widely recognized that different colors evoke distinct emotions due to associative learning; for instance, red often invokes feelings of vitality and enthusiasm due to its association with blood. The impact of color on emotional responses has not only been evident in psychological studies but also prominently featured in the arts, as seen in Monet's "Haystack" paintings [1]. These artworks vividly illustrate how color shifts can alter the emotional tone of the same scene, transitioning from the warm vitality of spring to the solitary cold of winter. Such shifts highlight the profound effect colors have on emotional perception and underscore the social significance of color research. The cultural background, environmental context, and personal preferences further modulate these emotional responses, making the study of color and emotions both complex and multidimensional.

Current Research Status: Recent studies have explored the relationship between color, emotion, and music, particularly in works like the Berkeley Color Project 32 (BCP-32) and related literature which delve into how these elements interplay to affect mood. For instance, in "Music–color associations are mediated by emotion," researchers provide a methodological framework for exploring how different colors correspond to various musical tones and the emotions they evoke.

Another significant study, "Color, Music, and Emotion: Bach to the Blues," employs a detailed experimental approach to segment participants into groups, facilitating a nuanced analysis of how color influences emotional responses to music. These methodologies offer valuable insights into the structured investigation of color-emotion associations and serve as foundational references for further empirical exploration in this field [2].

Research Content of This Study: Building on existing theories and methodologies, this study aims to investigate whether dynamic changes in color can influence human emotions. The focus is primarily on the nature of color transitions—both discrete and continuous—and the specific hues involved. By adapting the grouping techniques from previous studies, this research categorizes participants into fewer groups due to logistical constraints, yet aims to maintain the rigor of the experimental design. The application of these findings is also considered in broader contexts, such as film direction and genre-specific atmospheres in cinema, suggesting practical implications for using color to enhance emotional engagement and narrative depth. Through this experimental approach, the study seeks to contribute to a deeper understanding of dynamic color effects on emotional responses, paving the way for applications in various artistic and commercial fields.

2. Literature review

The relationship between color and emotion has been widely studied across various dimensions, including hue, saturation, and brightness. One study explores how these three dimensions of color impact emotional responses, suggesting that each component may evoke different feelings [3]. This research inspired adjustments to the experiment design, which incorporated dynamic changes in hue, saturation, and brightness to observe potential fluctuations in participants' moods. Other studies emphasize the connection between color, music, and emotion, indicating that emotional responses elicited by music can influence color associations. This concept underscores the idea that emotions themselves may serve as a bridge linking colors and musical elements, providing further insights into the complex interplay between sensory stimuli and emotional reactions.

Additional studies contribute valuable insights into the relationship between color and emotion, specifically regarding attentional bias and mood associations. Research on attentional bias highlights the influence of color on emotional responses to briefly presented images, while studies on mood associations examine the impact of color variations on emotional states, particularly among younger participants [4,5]. These findings offer foundational perspectives for understanding color-emotion associations from a psychological standpoint [6,7]. The theoretical framework established by these studies has been instrumental in shaping the experimental approach, ensuring a comprehensive exploration of color's impact on emotional responses [8,9]. Moreover, literature on cultural interpretations of color reveals how perceptions of color can vary significantly across different societies. For example, white is commonly associated with purity in Western cultures but is often linked to mourning in Eastern traditions [10]. Another study specifically examines the effects of varying red hues on mood, categorizing them as "cold," "neutral," and "warm" to analyze how subtle differences in hue can influence positive and negative emotional states. This understanding of hue variation was extended to other colors in the experiment, allowing for a nuanced examination of color-induced emotional responses [11]. These foundational studies collectively provide a robust framework for exploring the intricate connections between color and emotion in the current research.

3. Method

In this experiment, Berkeley Color Project 32 (BCP-32) was used to adjust the saturation, brightness and grayscale of 8 different basic colors respectively to form 32 color blocks, which is of great help to the researchers' experiment.

The researchers divided the participants into three groups: discrete high-saturation color changes (red-blue), continuous high-saturation color changes (yellow-violet), and continuous low-saturation color changes (yellow-violet). The discrete color change video (red-blue) is about 5 seconds long, the video starts with a highly saturated red color block, and then it suddenly changes to blue after a few seconds. A continuous high saturation color change video (yellow-violet) slowly changes from a high saturation yellow color block to a high saturation purple, while a continuous low saturation color change video only reduces the saturation of yellow and purple. Due to the limited number of people and space, these participants will conduct three experiments together.

The experiment used an open-ended questionnaire to survey 19 students aged 15-22, both male and female. The questionnaires were basically the same for all three experiments, and participants were asked to fill in their group number before watching the video. "ls" represents discrete, highly saturated color changes, while "lx" represents continuous, high-saturated or low-saturated color changes. They were then asked to fill in their color preferences: ranking them in the order of red, blue, yellow, and purple to minimize the emotional differences caused by color preferences. After watching the video, participants were asked to fill out the following questionnaire within 50 seconds: Whether they felt a change in emotion when the color changed. And the intensity of the changes: positive and negative emotions, calm and anxiety, dullness and vitality (on a scale of -3 to 3, negative numbers are bad mood and positive numbers are good mood). The greater the absolute value of this value, the greater the degree to which the participant feels different emotions) and the intensity (on a scale of 0-5, the greater the absolute value of this value, the greater the intensity of the participant's emotions) of the overall score.

In this way, researchers can avoid the emotional differences caused by color preference to the greatest extent; At the same time, the smaller variety of options and the smaller number of questions allowed participants to respond to the questionnaire from the bottom of their minds without pressure.

4. Result and Discussion

Through three experiments, the researchers calculated 19 different questionnaires and came to the conclusion that blue was the most preferred color and red was the least preferred color. These preferences may influence their emotional responses to color changes; Most participants reported a shift in their mood when the color changed, and the saturation of the color had a significant impact on the intensity of their emotional change.

At the same time, the researchers used the following formula to calculate the extent to which discrete color changes versus continuous study changes affect mood. The results show that the median values of these values are basically distributed around 1, which indicates that whether the color change is discrete or continuous has no significant effect on the change of human emotions. The results may have been influenced by the number of people and the limitations of the ve44nue.

$$
\begin{aligned}
\text{Change}_{\text{con}} &= |\ \text{Emotion}_e - \text{Emotion}_b\ | \\
&= |P_e - P_b| + |A_e - A_b| + |E_e - E_b| \\
\text{Change}_{\text{dis}} &= |\ \text{Emotion}_e - \text{Emotion}_b\ | \\
&= |P_e - P_b| + |A_e - A_b| + |E_e - E_b| \\
D/C &= \text{Change}_{\text{con}} / \text{Change}_{\text{dis}}
\end{aligned}
\tag{1}
$$

5. Discussion

After completing the research, an examination of the feasibility, validity, and reliability of the experiment is conducted. First of all, this experiment has a high feasibility, just let the subjects watch the video and then answer the questions, the experiment does not need to rely on complex research equipment. Secondly, the internal validity of the current experiment is low, because there are many

restrictions and confounding variables that cannot be controlled, which provides prospects to conduct a second trial. The external validity is high because the experiment was conducted in a more natural environment, the experiment involved a wide range of ages, and both men and women. The extent to which the results can be generalized to other environments, other people, and time is high. The internal reliability of this experiment is low, because the light in the classroom cannot be controlled, and the color projected on the large screen will be different from the actual color, which can also be solved with a better experiment in another trial. External reliability is high because we simply let the subjects watch the same video and there is no difference in color. All in all, a trial II involving more color changes for a longer period of time(like the seven rainbow colors) will potentially provide solid data to distinguish the emotion arousal by discrete or continuous changing. The environment should be designed in small dark rooms where less light disturbance is included, increasing internal reliability.

The low significance of discrete color changes versus continuous color changes may be due to the following limitations: First, because the survey sample is too small to form a reliable data collection, the choices made by each person will have a large impact on the average value. In addition, all participants are selected from the class based on accessibility rules, which can bring biases of gender, culture, and life background. In addition, because each participant performed three experiments successively, this could have led to an order effect. In the choice of color dimensions, researchers only designed two mutually changing tone dimensions in each video sample, which may not be enough to make participants get more emotional responses. At the same time, the video length of around five seconds may be another reason why the participants' mood changes were not significant, and their mood swings may have taken longer. What's more, the researchers only asked the participants to fill in the emotions they felt at the beginning and end of the video, ignoring the emotional changes as the colors changed. All these limitations can be taken into account in future studies.

6.   System Analysis and Application Research

Through this experiment, the researchers' conclusions can be widely applied to different fields, including photography, painting, film and advertising.

In photographic works, through the adjustment of the hue, saturation, brightness and even its change of the picture or video, people can better understand the meaning of the photographer. This is also true in paintings and animation works, and it is easier to express emotions: for example, people's first sight of a painting is directed to the red beginning, and then their eyes are directed to the blue part, resulting in changes in emotions. In the film industry similar to animation, the director can consider changing the above parameters to make viewers achieve the best immersive experience (experience the despair and fear of the protagonist in the horror film, or feel the fun with the film in the comedy) in different advertisements, such as the advertisement of a restaurant, the use of red color makes people feel more appetising; Or the use of blue tones in cleaning advertisements to make people feel that their cleaning is very clean.

Not only the above four fields, but also the emotional changes that humans feel about the static and dynamic changes of colors have many effects applied to various fields.

7.   Conclusion

This study explored the influence of dynamic color changes on human emotional responses by investigating variations in color saturation and transition modes, specifically utilizing discrete and continuous color changes. Through the application of the Berkeley Color Project 32 (BCP-32) within an experimental framework, the research demonstrated that while the mode of color change—whether discrete or continuous—did not significantly impact emotional responses, variations in color

saturation did indeed influence the intensity of these responses. This indicates that the intensity and vividness of a color play a critical role in affecting human emotions, more so than the manner in which colors transition from one to another.

Directions for Future Research: Building on the findings of this study, several avenues for future research have been identified to deepen and expand our understanding of how color dynamics influence emotional states:

- Expanded Participant Diversity: Future experiments could benefit from a more diverse participant pool, encompassing a broader range of cultural backgrounds and age groups to enhance the generalizability of the findings.
- Extended Experimental Duration and Complexity: Incorporating a wider range of colors and extending the duration of color exposure could provide more insights into how prolonged or complex color dynamics interact with emotional responses.
- Integration of Multimodal Sensory Inputs: Future studies could explore the combined effect of colors with other sensory stimuli—such as sound and texture—to examine how multimodal interactions influence emotional outcomes.
- Technological Enhancements in Experimentation: Utilizing advanced display technologies to ensure color accuracy and consistency across all experimental setups could enhance the reliability of future research.
- Real-Time Emotional Tracking: Implementing technologies that track emotional changes in real-time during color exposure could provide a more detailed understanding of how immediate shifts in color impact feelings and mood states.

References

[1]   Palmer, S. E., Schloss, K. B., Xu, Z., & Prado-León, L. R. (2013). Music–color associations are mediated by emotion. Proceedings of the National Academy of Sciences, 110(22), 8836-8841.
[2]   Whiteford, K. L., Schloss, K. B., Helwig, N. E., & Palmer, S. E. (2018). Color, music, and emotion: Bach to the blues. i-Perception, 9(6), 2041669518808535.
[3]   Wilms, L., & Oberfeld, D. (2018). Color and emotion: Effects of hue, saturation, and brightness. Psychological Research, 82(5), 896-914.
[4]   Kaya, N., & Epps, H. H. (2004). Relationship between color and emotion: A study of college students. College Student Journal, 38(3), 396-405.
[5]   Bekhtereva, V., & Müller, M. M. (2017). Bringing color to emotion: The influence of color on attentional bias to briefly presented emotional images. Cognitive, Affective, & Behavioral Neuroscience, 17, 1028-1047.
[6]   Lawler, C. O., & Lawler III, E. E. (1965). Color-mood associations in young children. The Journal of Genetic Psychology, 107(1), 29-32.
[7]   Zhu, X., Guo, C., Feng, H., Huang, Y., Feng, Y., Wang, X., & Wang, R. (2024). A review of key technologies for emotion analysis using multimodal information. Cognitive Computation, 1(1), 1-27.
[8]   Hanada, M. (2018). Correspondence analysis of color–emotion associations. Color Research & Application, 43(2), 224-237.
[9]   Wang, R., Zhu, J., Wang, S., Wang, T., Huang, J., & Zhu, X. (2024). Multi-modal emotion recognition using tensor decomposition fusion and self-supervised multi-tasking. International Journal of Multimedia Information Retrieval, 13(4), 39.
[10] Cherry, K. (2024). Color psychology: Does it affect how you feel? Dotdash Media, Inc.
[11] Albert, A. (2007). Color hue and mood: The effect of variation of red hues on positive and negative mood states. College of St. Elizabeth Journal of the Behavioral Sciences.