A Sensory Engineering Study on the Impact of Warm and Cool Color Posters on College Students Emotions

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Abstract. This study is based on the theory of human engineering psychology and explores the mechanism by which cool and warm color posters affect the emotions of college students. Through the combination of experimental methods and scale measurement, 60 college students were selected as participants. Cool color (blue, green) and warm color (red, yellow) posters were randomly presented to them, and their emotional responses were collected. The SAM scale (Self-Assessment Manikin) was used to assess the degree of pleasure, arousal, and dominance, and skin conductance response (GSR) was used to obtain physiological indicators to enhance the objectivity of the study. The results showed that warm color posters significantly enhanced the arousal and pleasure of college students, especially under the red stimulus, with the highest level of emotional activation. While cool color posters significantly reduced arousal and brought a more calm and relaxed emotional experience. The blue tone was the most effective in alleviating anxiety. Gender and professional background have a moderating effect on color perception. Women are more sensitive to the emotional responses to cool and warm colors, and students majoring in art design have a higher recognition and emotional response intensity of color differences than non-art majors. This study verified the applicability of color emotional effects in the college student population and expanded the application boundaries of human engineering psychology in visual communication design. The research suggests that in college mental health publicity and campus environment design, scientific application of color psychology principles should be adopted, and appropriate colors should be selected according to different emotional regulation goals to improve the accuracy and effectiveness of emotional intervention. In the future, neuroscientific methods such as electroencephalogram (EEG) can be further introduced to deeply reveal the neural basis of the color emotional mechanism.

Keywords: human engineering psychology, Cool and warm color, College students emotion, sensory engineering.

1. Introduction

As the most fundamental stimulus in the living environment of living beings, color has an impact on the emotions of both animals and humans. Previous researchers have conducted extensive studies on the influence of color on emotions, and the results have shown considerable differences; among them, the most studied and also the most controversial issue is the impact of red and blue on emotions.

In the theory of emotions, emotions are classified into three dimensions: valence (pleasure), arousal (excitement), and dominance (control). Valence refers to whether the emotion is positive or negative, ranging from pleasure to displeasure; arousal refers to the physiological arousal level of the emotion, ranging from excitement to calmness; dominance refers to whether the individual can control, dominate, or be in a superior position when experiencing this emotion, ranging from dominance to subordination.

Previous studies have shown that in terms of emotional arousal, the results of most behavioral experiments and skin conductance experiments indicate that long-wave colors (such as red and yellow) have a higher arousal level than short-wave colors (such as blue and green), that is, red can trigger a higher level of arousal than blue. In terms of emotional dominance, there are fewer studies on red and blue. However, studies have shown that red can stimulate the secretion of testosterone in male animals and enhance their dominance. Wearing red sports clothes is more likely to boost the sense of superiority of male athletes in sports competitions, thereby increasing their chances of winning. This suggests that red is more likely to trigger emotions with high dominance (such as confidence, ambition, etc.). Regarding the degree of emotional pleasure, most research results indicate that short-wavelength colors have a higher degree of pleasure than long-wavelength colors. However, when it comes to red and blue specifically, there is a significant divergence in the research results: Some studies suggest that red can trigger positive emotions, while blue can trigger negative emotions. For instance, Garth et al. [4] conducted a study which indicated that both Filipinos and Native Americans in the United States preferred red and consider it to have the strongest sense of pleasure. Hevner et al. [6] discovered that red evoked excitement while blue evoked sadness. However, other studies had shown that blue could trigger positive emotions, while red could trigger negative emotions. Gerend et al.'s [5] research found that red was associated with negative emotions and thereby affected the persuasive effect. Spielberger et al. [6] used the state anxiety questionnaire method to measure that people are most anxious when seeing red and yellow, and more relaxed when seeing blue and green. In summary, the academic research on the effects of different colors, especially red and blue, on emotions has both consensus and controversy. The main controversy comes from the impact of red and blue on the degree of emotional pleasure. Some studies have concluded that red triggers positive emotions and blue triggers negative emotions, while other studies have found evidence that blue triggers positive emotions and red triggers negative emotions.

Previously, the relationship between color and emotion is mainly explained through the learned association theory. This theory holds that colors exert an influence on psychological activities (emotions, cognition, behavior) through learned associations that are rooted in deep psychological tendencies. From infancy, humans have been consciously or unconsciously experiencing the associative connections between colors and various information, concepts, objects, and situations. When such associative connections occur repeatedly, color associations are formed. Therefore, when people encounter a certain color in a specific environment, they will spontaneously and unconsciously activate the acquired associations related to that color, thereby influencing their mental activities. This theory has received evidence from studies on "the influence of colors on behavior" [4]. In particular, the research results of Mehta et al. [4] indicated that red and blue trigger different motivations through different acquired associations, and thereby had an impact on different types of cognitive tasks. This study had two important implications: Firstly, it further proved that colors trigger different types of motivations by activating different acquired associations; secondly, more importantly, this study proposed and to some extent verifies that different motivations triggered by different colors were related to people's life experiences. That is, colors influence mental activities through acquired associations formed in the living environment.

2. The Sensory Engineering Research on Color Psychology

From the previous section's discussion on color psychology, it is easy to see that colors can have a profound impact on people in various aspects. How to incorporate color factors into UI design to achieve a favorable effect that is conducive to users completing their task goals is an important issue. After conducting research on the relationship between the environment and production efficiency, the researchers proposed that colors have the following functions in the process of creating an ideal environment [28].

- Improve production efficiency.
- Enhance security.
- Increase comfort.
- Stimulate the enthusiasm for work.

As the main environment for operating digital products, the color design of the user interface also needs to pay attention to the above four aspects of issues. When choosing colors for UI design, it is necessary to consider the scenarios in which the characters use the product. Select colors that can help users achieve their goals in these scenarios. Based on the influence of colors on the human psyche, the color design in the visual design of the user interface can be correlated with the psychological effects of colors, providing appropriate color schemes for specific designs.

2.1. The Coldness and Warmth of Colors

People's perception of the coldness or warmth of colors is derived from the long-term influence of temperature changes in the natural environment and the color changes of the environment on human beings. For instance, red-hot steel emits orange light, while frozen ice blocks emit blue light; the sun is orange-yellow, and the areas not illuminated by the sun are cold gray. It is precisely this long-term relationship between color and temperature that enables people to have the concept of coldness and warmth in their perception of colors.

Do colors like red, orange, and yellow remind you of sunlight and the warm feeling of fire? So they are called "warm colors". Green, cyan, and blue are related to coldness and darkness, so they are called "cool colors". Red gives people an active and lively warm feeling. Blue gives people a calm and negative feeling. Green and purple are neutral colors, with little stimulation and an effect between red and blue. Neutral colors make people feel relaxed and can avoid the feeling of fatigue. People's perception of the coldness or warmth of colors basically depends on the hue. From the perspective of color's three-dimensionality, the higher the saturation of warm color tones, the more obvious the warm feeling; while the higher the brightness of cool color tones, the more obvious the cold feeling.

2.2. The Weight of Color

Color can also give people a sense of heaviness or lightness. For instance, suppose there are two squares, one black and one white. They have the same shape, volume and weight. But the black square makes people feel it is heavier than the white one. Many examples prove that different colors give people very different feelings of heaviness. The sense of weight people get from colors is a combination of texture and color perception. Generally speaking, light colors have a lower density and give a sense of floating upwards, making people feel lighter. Dark colors have a higher density and give a sinking feeling, making people feel heavier.

2.3. The Feature of Color

With the socialization of color associations, colors have increasingly become symbols with certain meanings. The content of people's associations has also become more specific and abstract, or emotional. When colors become symbols with universal significance, they will give people the same imagination. Colored symbols play an important role in daily life. For example, the clothes worn by medical staff are all white, and wedding dresses are also white, because white symbolizes purity and cleanliness. It should be noted that people from different cultural backgrounds and in the international community have different meanings for colors. For instance, in Chinese culture, black symbolizes death. However, in the Western world, black symbolizes professionalism. Even so, most societies have similar symbolic meanings for colors.

According to the different environments in which different users are located, different colors are adopted in the visual design of the user interface to adapt to the usage environment, generate beneficial associations, and avoid unfavorable symbols.

2.4. User Interface Sample Collection and Color Psychology Color Extraction

The colors typically included in a general user interface are usually more than one. The color combinations of the user interface of mature commercial digital products usually have one hue as the main color, supplemented by other colors of the same color family with different brightness or saturation, or complementary colors to enrich the interface. Therefore, the color psychology of the user interface is not simply the color psychology generated by the color hue, but mainly based on the color psychology generated by the main color family, with the color psychology generated by the auxiliary colors as a deviation. The model establishment of the color psychology of the user interface can be done by collecting a certain number of existing mature commercial UI interfaces as samples, and then extracting three representative colors for each interface. Use the color psychology of the main hue to analyze and classify the color psychology of the existing commercial UI interfaces. Sort the classification results, and then match the perceptual ergonomics attributes of each user interface sample with the color psychology of the main color family to establish a comparison model of interface attributes and color psychology.

In this stage, the collection of emotional vocabulary groups and interface samples needs to be completed. The quantity of emotional vocabulary and interface samples will to some extent affect the quality of the experimental data. Missing out on even one emotional vocabulary or one interface sample could potentially impact the validity of the research. Therefore, during this process, 26 members with relevant design experience were invited to form an expert group.

After removing some offline and shell-like apps, a total of 356 valid tourism-related app samples were collected. To reduce the influence of the test subjects' original familiarity and favorability towards a specific app, the visual elements of the app interfaces included in the sample were collected and extracted for the experiment. The extracted content included the color of visual elements, icons, and the overall layout.

First, the extraction of color elements. Colors are mainly constructed by extracting the main color, transitional color and auxiliary color of the interface to form color block samples. Based on the principle of eliminating similarities, similar color combinations are selected, and the remaining color blocks are classified and sample determined as shown in Figure 1.

Second, extraction of icon elements. During the process of extracting sample elements, it is found that the physical photography type, color hand-drawn type, and minimalist line type are the most commonly used icon forms in the interface of tourism-related APPs. Finally, 9 representative samples are selected, as shown in Figure 2.

Third, extraction of overall layout. The status bar, navigation bar, main menu bar and content area are the components of an APP interface. During the research, it was found that the layout of the content area in an APP interface generally consists of three parts: the promotional area, the icon area, and the introduction of distinctive features. Therefore, the experiment grouped and summarized the details according to these parts, selected representative interface prototypes, and created layout sketches.

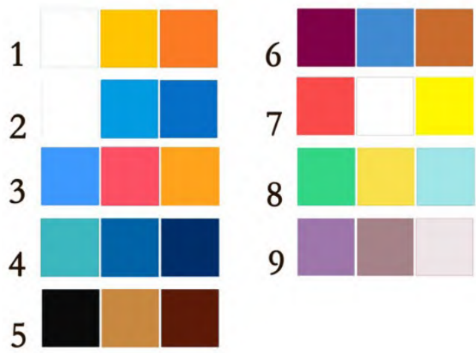

Fig. 1. Extraction of color element samples

Fig. 2. Icon element extraction

Furthermore, the collection of emotional words mainly involves extensive gathering of words related to the design imagery through methods such as consulting relevant product literature, reading newspapers or periodicals, participating in group discussions, and conducting brainstorming sessions. From this pool of words, those that are not frequently used or have similar meanings are eliminated, and the most appropriate words are selected that are closely related to the visual elements. Eventually, the members of the expert group vote to select the corresponding word groups for colors as ”warmth and coldness” and ”brightness and darkness”; for layout, the corresponding word groups are ”compact and loose” and ”simple and complex”; for icons, the corresponding word groups are ”abstract and concrete” and ”simple and complex”.

3. Experiments Part

This stage is the specific experimental part. The tourism APP is used as the test object. Starting from the specific to the general, an effective experimental process is explored. The experiment specifically adopts a five-point scale to conduct data research on the perception preference and perception bias of visual elements: on one hand, to understand the audience’s preference bias for visual elements; on the other hand, to complete the audience’s perception bias of visual elements. Through the research of these two parts, it is possible to understand the audience’s preference for the visual interface more intuitively and clearly, and can use the closest samples as important references, thereby providing certain help and references for the design and development of the APP visual interface. The research is conducted through online questionnaires, and a total of 161 questionnaires (Tables 1 and 2) are collected. Among them, there are 75 men and 86 women. The distribution of age groups is as follows: 17 people under 20 years old, 118 people between 20 and 35 years old, 23 people between 35 and 50 years old, and 3 people over 50 years old.

Table 1. Survey sample gender information table

Item	Frequency	Effective Percentage
Men	75	46.58%
Women	86	53.42%
Total	161	100%

First, the results of the color research indicate that the audience’s perception and preference for colors tend to be warmer and brighter. The ”Warm vs. Cold” group (Table 3) shows that the average score for the audience’s color

Table 2. Survey sample gender information table

Age	Frequency	Effective Percentage
< 20	17	10.56%
$20 - 35$	118	73.29%
$35 - 50$	23	14.29%
> 50	3	1.86%
Total	161	100%

preference is 0.68, which is between the average and the warmer category, slightly leaning towards the warmer category. The color perception bias survey of the corresponding samples shows that samples 1, 3, 7, and 8 have a warm color preference, while the others have a cold color preference. From the data range, the survey results of samples 3 and 8 fall within the same preference range as their preferences; from the absolute values of the two sets of data, sample 3 is the closest.

Table 3. Preference and perception Bias for "Warm-Cold" preferences

Item	2	1	0	-1	-2	Average score	Absolute value
Warm/Cold	48(29.81%)	42(26.09%)	48(28.57%)	21(13.04%)	4(2.48%)	0.68	none
Sample 1	56(34.78%)	59(36.65%)	41(25.47%)	4(2.48%)	1(0.62)	1.02	0.34
Sample 2	3(1.86%)	7(4.35%)	40(24.84%)	49(30.43%)	62(38.51%)	-0.99	1.67
Sample 3	25(15.63%)	64(39.75%)	59(36.65%)	10(6.21%)	3(1.86%)	0.61	0.07
Sample 4	2(1.24%)	5(3.11%)	22(13.66%)	63(39.13%)	69(42.86%)	-1.19	1.87
Sample 5	5(3.11%)	42(26.09%)	66(40.99%)	24(14.91%)	24(14.91%)	-0.12	0.8
Sample 6	3(1.86%)	20(12.42%)	81(50.31%)	50(31.06%)	7(4.35%)	-0.24	0.92
Sample 7	72(44.72%)	57(35.40%)	32(19.88%)	0	0	1.25	0.57
Sample 8	21(13.04%)	38(23.60%)	65(40.37%)	30(18.63%)	7(4.35%)	0.22	0.46
Sample 9	3(1.86%)	36(22.36%)	66(40.99%)	52(32.30%)	4(2.48%)	-0.11	0.79

The "Bright-Dark" group (Table 4) has an average survey result score of 0.94, which falls between the average and the brighter category. They tend to prefer the brighter category. The color perception bias survey of the corresponding samples shows that except for samples 4, 5, 6, and 9, the rest are all inclined towards brighter colors. The survey result of sample 8 falls within the same preference range as the preference degree. From the absolute values of the two sets of data, sample 8 is the closest.

Table 4. "Compact-Loose" preference degree and perception bias

Item	2	1	0	-1	-2	Average score	Absolute value
Compact/Loose	14(8.7%)	9(5.59%)	75(46.58%)	46(28.57%)	17(10.56%)	-0.27	none
Sample 1	18(11.18%)	39(24.22%)	97(60.25%)	4(2.48%)	3(1.86%)	0.4	0.67
Sample 2	3(1.86%)	20(12.42%)	33(20.50%)	54(33.54%)	51(31.68%)	-0.81	0.54
Sample 3	33(20.50%)	66(40.99%)	30(18.63%)	24(14.91%)	8(4.97%)	0.57	0.84
Sample 4	5(3.11%)	16(9.94%)	42(26.09%)	50(31.06%)	48(29.81%)	-0.75	0.48
Sample 5	3(1.86%)	33(20.50%)	70(43.48%)	40(24.84%)	15(9.32%)	-0.19	0.08
Sample 6	82(50.93%)	51(6.21%)	15(9.32%)	12(7.45%)	1(0.62%)	1.25	1.52
Sample 7	72(44.72%)	33(20.50%)	33(20.50%)	18(11.18%)	5(3.11)	0.93	1.2

The "Concrete to Abstract" group (Table 5) shows that the average score for the audience's preference for icons is 0.06, which is between average and more concrete items, and slightly favors the more concrete items. The icon perception bias survey of the corresponding samples shows that except for samples 1, 3, 5, 7, and 8 whose survey results and preference tendencies fall within the same range: from the absolute values of the two sets of data, sample 7 is the closest. 2 and 9 are excluded, the rest are more figurative; from the perspective of the data range, sample

Table 5. "Concrete-Abstract" preference and perception bias

Item	2	1	0	-1	-2	Average score	Absolute value
Bright/Dark	51(31.68%)	57(35.4%)	46(28.57%)	7(4.35%)	0	0.94	/
Sample 1	90(55.90%)	51(31.68%)	15(29.32%)	5(3.11%)	0	1.4	0.34
Sample 2	64(39.75%)	70(43.48%)	19(11.80%)	5(3.11%)	3(1.86%)	1.16	0.22
Sample 3	60(0.37%)	69(42.86%)	24(14.91%)	8(4.97%)	0	1.06	0.12
Sample 4	11(6.83%)	21(13.04%)	57(35.40%)	60(37.27%)	12(7.45%)	-0.25	1.19
Sample 5	0	1(0.62%)	24(14.91%)	54(33.54%)	82(50.93%)	-1.35	2.29
Sample 6	3(1.86%)	10(6.21%)	66(40.99%)	70(43.48%)	12(7.45%)	-0.48	1.42
Sample 7	99(61.49%)	46(28.57%)	13(8.07%)	3(1.86%)	0	1.5	0.56
Sample 8	36(22.36%)	75(46.58%)	42(26.09%)	6(3.73%)	2(1.24%)	0.85	0.09
Sample 9	1(0.62%)	30(18.63%)	64(39.75%)	60(37.27%)	6(3.73%)	-0.25	0.19

4. Conclusion

Conclusion

This study, based on the principles of human engineering, systematically explored the mechanism by which warm and cool color posters affect the emotions of college students. Through controlled experimental design, combined with the subjective emotion scale (SAM) and objective physiological indicators (GSR), the emotional responses of 60 college students after viewing warm and cool color posters were collected and analyzed. The research results show that warm color (red, yellow) posters significantly enhanced the pleasure and arousal levels of college students, especially under the stimulation of red, with the highest level of emotional activation; while cool color (blue, green) posters effectively reduced arousal levels, bringing a calm and relaxed emotional experience. Among them, blue was the most effective in alleviating anxiety. Further analysis revealed that gender and professional background exert a moderating effect on the perception of color emotions. Female participants showed a more sensitive response to warm and cool tones in terms of emotional reactions, especially in the regulation of negative emotions; students majoring in art design, due to their higher color recognition ability, exhibited significantly stronger emotional response intensity than those from non-art-related majors. This finding suggests that the color emotional effect is not uniform but is regulated by individual experience and cognitive background. This study verified the applicability of the color emotional effect among Chinese college students at the theoretical level, expanding the application boundaries of sensory ergonomics in the intersection of visual communication and mental health; at the practical level, it provided empirical-based color strategy suggestions for college mental health intervention, campus environment design, and publicity poster production. Future research can further introduce neuroscientific methods such as electroencephalography (EEG) to deeply reveal the neural basis of the color emotional mechanism and expand the sample types to enhance the universality and precision of the research conclusions and intervention strategies.

5. Conflict of Interest

The authors declare that there are no conflict of interests, we do not have any possible conflicts of interest.

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