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How to Make Flower Borders Benefit Public Emotional Health in Urban Green Space: A Perspective of Color Characteristics

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Abstract: The emotional health benefits of urban green space have been widely recognized. Flower borders, as a perennial plant landscape, have gradually become a current form of plant application in urban green spaces due to their rich color configurations. However, the related research primarily focuses on the impact of urban green spaces on public health, with relatively little attention given to how the colors of flower borders affect public emotional health. This study explored the relationship between the flower borders color characteristics and the public emotional health. In this study, 24 sample images were used as experimental materials, which selected based on their color richness and harmony. Additionally, face recognition technology and online random questionnaires were utilized to measure the public basic emotions and pleasure, respectively. The result shows that, based on the HSV color model and expert recommendations, 19 color characteristics were identified. The correlation analysis of the results from the public emotion with these color characteristics revealed that 13 color characteristics correlated with public emotional pleasure. Among them, blue, neutral purple, and low saturation were positively correlated. Through factor analysis, these thirteen color characteristics were summarized and categorized into four common factors (F1–F4), three of which are related to color. They are "low saturation of blue-violet percentage" (F1), "color configuration diversity" (F2), "bright red percentage" (F3), and "base green percentage" (F4), with F1 having the largest variance explained (27.88%). Finally, an evaluation model of color characteristics was constructed based on the variance explained by these four factors, which was demonstrated to effectively predict the level of public emotional pleasure when viewing flower borders. The results shed light on the effects of color characteristics on public emotions and provide new perspectives for subsequent flower border evaluations. Our results provide a valuable reference for future flower border color design, aiming to better improve public emotional health.

Keywords: flower border; urban green space; public emotional health; color characteristics; factor analysis

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Citation: Wan, Z.; Shen, X.; Cai, Y.; Su, Y.; Ren, Z.; Xia, Y. How to Make Flower Borders Benefit Public Emotional Health in Urban Green Space: A Perspective of Color Characteristics. *Forests* **2024**, *15*, 1688. https://doi.org/10.3390/f15101688

Academic Editor: Remus Crețan

Received: 6 August 2024
Revised: 19 September 2024
Accepted: 20 September 2024
Published: 25 September 2024

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1. Introduction

With the rapid development of society, the process of urbanization, and the ever-increasing pace of modern life, city people are usually confronted with a series of health problems, especially mental health problems. As the stresses of life continue to accumulate, negative emotions grow, causing many people to feel anxious and uneasy, leading to an increase in psychological stress and related mental problems [1,2]. These trends emphasize the need for sustainable and healthy living patterns [3,4]. In the search for solutions to people's mental health problems, it has been found that urban green space (e.g., parks, urban greenways, etc.) plays an increasingly important role in promoting human well-being and mental health [5–8]. Urban green spaces are not only an important part of the

urban ecosystem and urban landscape, but are also places for people's daily rest, recreation, and exercise. A large number of studies have confirmed that urban green space, as a kind of "restorative environment", not only enriches the aesthetic experience of people's daily lives, but also effectively alleviates negative emotions and improves their moods, which are significant for promoting both physiological and psychological health [9–22]. The current research on the impact of urban green space on mental health focuses on three main areas: the impact of urban green space as a whole, green and blue spaces, and soundscapes in urban parks on people's emotional health [23–25]. As research deepens, people's understanding of urban green space is also increasing, which means that the design standards for urban green space also need to be further improved. Plants are an important part of urban green spaces, and the attractiveness of urban green space is closely related to the characteristics of its plants, such as the species, configuration, and color [8]. In recent years, decorative planting patterns based on the expression of plant landscape details have gradually become the focus of modern garden environment construction [26].

Color, as an important expressive feature of plants, plays a vital role in plant landscapes. The harmony and beauty of the color combinations directly affect the quality of the landscape [27]. Similarly, the richness of the plant color influences the public's assessment of the planted landscape [28]. Plant colors still play an important role in emotional health [29,30]. As the most diverse element in nature, color can give the public different emotional perceptual experiences. Color, as a fundamental aspect of human perception, is probably the most important visual attribute that influences emotional perception [31]. For example, cool colors such as blues, greens, whites, and soft colors create a calming experience, while bright reds, yellows, oranges, and other vibrant colors invigorate by distracting the attention [32]. Most current research focuses on the effect of a single color on emotions, but ignores the comprehensive effect of color combinations on emotions. The interaction between colors can also have a profound effect on emotions, which deserves further research and exploration. In recent years, flower borders, as a kind of small-scale plant landscape integrating ornamental value and ecological advantages, have shown greater potential for increasing plant and landscape diversity. With their rich and varied colors and the ability to create a natural, layered visual effect, flower borders have become a major form of plant landscape in cities. Currently, studies on flower borders mainly focus on the influence of the color of the plants themselves on the public's aesthetic preference or visual behavior [33,34] and also on the promotion of insect pollination from the biodiversity of flower borders [35]. Most of the studies still use larger scale plant combinations as experimental materials to study the color combination relationship among different plants [36]. However, due to the unique color composition and characteristics of flower borders, the existing understanding of plant color's influence on emotions may not be directly applicable to predicting the public's emotional response to flower borders. This study will focus on the relationship between the flower border color characteristics and public emotional health.

Face recognition, as a novel technique, analyzes the visual record of a face using a software algorithm generated by training a model with big data on the expected emotional expressions [37]. This provides a more objective technical approach to studying the effects of plant color on emotions. The initial step in the emotion recognition process involves detecting and aligning faces in the video frames. The facial features are then extracted, and the emotion categories are calculated by ResNet50 (a convolutional neural network that is 50 layers deep). The current technology can achieve an accuracy of facial analysis as high as 87% in perceiving emotions [38]. It has been widely used in studies exploring emotional connections between people and nature [39,40].

This study aims to investigate the relationship between flower border color characteristics and public emotional health in current urban green space. Different types of flower borders are fully considered in this study, and typical images are selected to analyze the effects of their color factors on public emotions. The research questions include the following:

(1) What is the relationship between flower border color characteristics and basic public emotions?
(2) Which color characteristics significantly affect public emotional pleasure?
(3) What is the relationship between public emotional health and flower border color characteristics?

The results of the study will help to better enhance the quality of flower borders in urban green space, improve the public emotional health, and provide guiding recommendations for future flower border design.

2. Materials and Methods

2.1. Stimuli

In this study, photographic images were used as a surrogate for real flower borders, as the effectiveness of this method has been widely demonstrated [41–43]. All photographs were taken by one of the authors using a Sony Alpha 7R II digital camera (Sony Corporation, Tokyo, Japan) in many urban green spaces. The images were converted to a resolution of 3936 × 2214 pixels using Adobe Photoshop 2021 software. Elements such as lawns and the sky were removed from the images to prevent interference. Additionally, the first image taken was used as a baseline for color correction to ensure that all experimental images maintained approximately the same color style.

In the selection process of experimental images, we fully considered various types of flower borders. To avoid the influence of specific elements, styles, and unique designs on the later observation experiments, the sample images selected for this research featured natural contour lines, free combinations of plant patches, no special geometric arrangements, and no sculptures, structures, or other landscape elements. Color richness and color harmony were used as the selection criteria for experimental materials [27,36]. Color richness is reflected in the number of color blocks, the number of colors, and the number of plant species. We selected representative images based on four criteria: low, slightly low, slightly high, and high. Color harmony refers to the harmonious relationship of each color in an image and can be broadly classified into three types: monochrome, bicolor, and mixed color. Monochrome usually refers to the same color and neighboring colors (the angle in the color ring is about 0–60°). Common monochromatic combinations in flower borders include yellow-orange, blue-violet, orange-red, and yellow-green, often referred to as warm, cool, and neutral colors. Bicolor combinations include contrasting and complementary colors (the angle between two colors in the color ring is about 120°–180°). We selected the two most commonly used bicolor combinations: "red-orange & yellow-green" and "orange-yellow & blue-violet". Finally, a total of 24 images were selected as experimental materials (Figure 1).

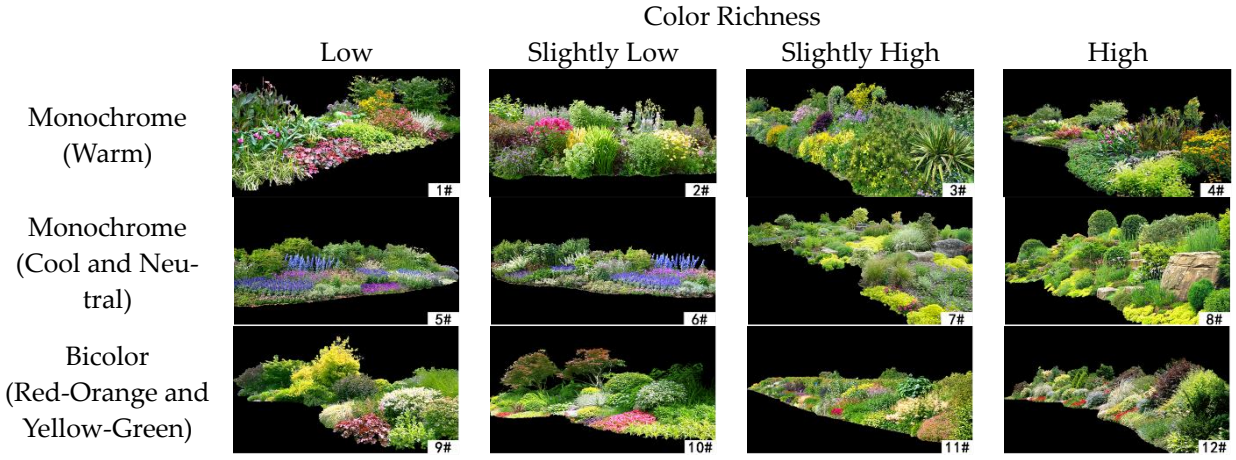


Figure 1. *Cont.*

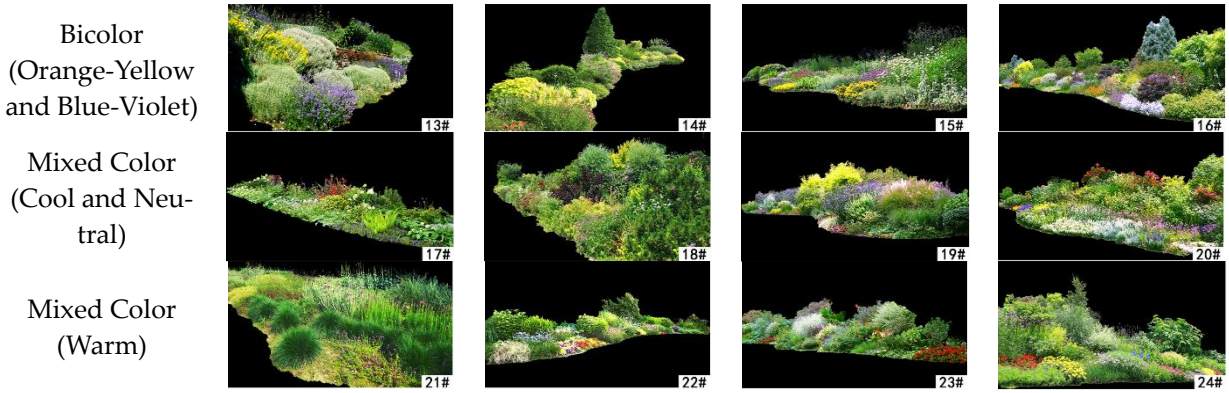


Figure 1. Representative images selected based on color richness and color harmony, and 1#–24# are the 24 images for this study.

2.2. Emotion Perception Experiment

We randomly invited 60 participants (30 males and 30 females) to participate in our emotion perception experiment. The experiment was conducted to determine the effect of the stimuli on participants' emotions by recording their facial expressions when viewing the stimuli. All participants were thoroughly informed about the entire experimental procedure and the functionality of the equipment used. Before deciding to participate, all volunteers were asked to read and sign an informed consent form to ensure they fully understood the details of their involvement in the study. During the experiment, participants were seated 70 cm in front of a height-adjustable 32-inch full HD monitor on a desk in a comfortable setting. The experiment involved the display of 24 visual stimuli images. Each trial began with an 8-s display of the stimulus image, followed by a 10-s display of a white image for rest. This process was repeated throughout the trial, which concluded with an additional 5-s display of a black image to signify the end of the experiment (Figure 2). At the end of the experiment, we collected demographic information from the participants and provided each with a reward of RMB 10.

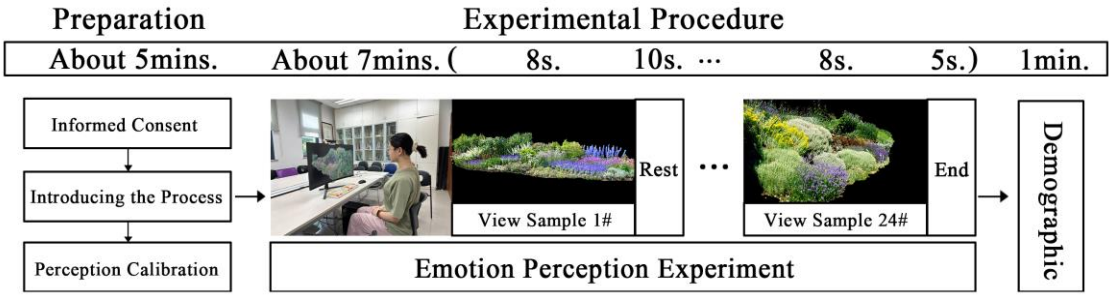


Figure 2. Preparation and experimental procedure.

2.3. Public Emotional Pleasure Measurement

With the continuous development of the Internet, questionnaire surveys have evolved from traditional offline methods to online formats. In this experiment, data on public emotional pleasure when viewing flower borders were primarily obtained through online questionnaire surveys (Figure S1). This method, widely adopted by previous researchers, is generally recognized for its reliability [44,45]. To minimize misunderstandings among participants, emotional pleasure was defined as the extent to which they enjoyed viewing the flower borders in the pictures at the time of the questionnaire. Participants were asked to rate the 24 pictures on a 5-point scale from "5 = very happy" to "1 = very unhappy". Before starting the questionnaire, subjects provided demographic information, including gender, occupation, and education.

A total of 311 online questionnaires were randomly distributed, and responses that were too long, too short, incomplete, or contained unusual values were removed. The entire questionnaire only collects the emotional responses of the participants while completing the questionnaire; the demographic information of the participants does not have an impact on the final results. This resulted in 281 valid questionnaires. The demographic information showed a slight majority of female participants, with most participants aged between 18 and 55.

2.4. Flower Border Color Characteristics Selection and Quantization

The HSV color model is more consistent with the human eye's perception of color, so this study adopts the HSV color model as a standard to quantify the color of flower borders. By reviewing the literature [34,46], a total of 384 colors can be obtained if the H, S, and V components are uniformly quantized at 24, 4, and 4 levels of non-equivalence, respectively, and normalized to black, white, and gray. We adjusted the criteria for the division of the color ring, and, based on other relevant literature and the suggestions of flower border experts, selected a total of 19 color factors for this study, as shown in Table 1.

Table 1. The color characteristics of the flower borders.

Color Factors	Abbreviation	Value Range
Hue		
Red	C1	0–1
Orange	C2	0–1
Yellow	C3	0–1
Yellowish-Green	C4	0–1
Neutral-Green	C5	0–1
Blue-Green	C6	0–1
Blue	C7	0–1
Neutral Purple	C8	0–1
Purplish-Red	C9	0–1
Saturation		
Low saturation	S1	0–0.25
Medium saturation	S2	0.25–0.5
Medium-High saturation	S3	0.5–0.75
High saturation	S4	0.75–1
Value		
Low value	V1	0–0.25
Medium value	V2	0.25–0.5
Medium-High value	V3	0.5–0.75
High value	V4	0.75–1
Other Factors		
Number of plant patches	NPP	>1
Proportion of flowering plant patches	PFPP	0–1

The color factors in the sample images were statistically recorded according to three categories: monochrome, bicolor, and mixed color. The preliminary processed pictures were imported into Python 3.11.3 [36,47], where they were divided into hue, saturation, and numerical values, and the pixel values of each color factor were calculated. The quantification results of the color factors for 24 images were obtained using Excel 2021.

Finally, the quantitative factors of the flower borders mentioned above are summarized as the flower border color characteristics.

2.5. Statistical Analysis

Data analysis was divided into image data extraction and analysis, public basic emotions identification, questionnaire data analysis, and the construction of the evaluation model of the color characteristics of the flower border. All statistical analyses were performed using SPSS 27 software. Through Pearson correlation analysis, we selected the color factors with significant correlations to seven basic emotions and public emotional pleasure. By comparing the results of the two experiments, we believe that the color factors related to the public emotional pleasure can more accurate and comprehensive reflect the overall color of the flower border. Four common factors related to public emotional pleasure were then extracted using factor analysis, and each common factor was named according to its color characteristics. At the same time, we obtain the coefficient matrix of the color factor components based on the regression analysis algorithm and obtain the expressions for the scores of the four common factors. Finally, an evaluation model of color characteristics was constructed based on the variance explained by these four common factors. To further verify the accuracy of the evaluation model, we randomly selected 10 domestic and international flower border cases as samples (Figure S3) and randomly invited participants (N = 105) to rate the viewing pleasure of the flower borders via the online questionnaire (the scoring criteria, experimental procedure, and statistical analysis were exactly the same as in previous experiments).

3. Results

3.1. Relationship between the Color Characteristics and the Public Emotions

The video frames captured when people viewed the image stimuli were analyzed for seven basic emotions: sadness, neutral, disgust, anger, surprise, fear, and happiness. We performed a Pearson correlation analysis between these seven basic emotions and the color factors extracted from the images. As shown in Table 2, these emotions had significant correlations with PFPP, C1, C2, C3, C5, C7, C8, C9, V1, V2, V3, V4, S1, S3, and S4 ($p < 0.05$). Among them, happiness was significantly correlated with PFPP, C5, C7, C8, C9, V4, S1, and S3 ($p < 0.05$), while surprise was significantly correlated with C5, C7, C8, C9, V4, and S1 ($p < 0.05$). As for the emotion neutral, it is mainly related to the value of the color. (V1–V4, $p < 0.05$) Among the selected negative emotions, C1, C2, C3, C5, V1, V2, and S4 were significantly correlated with anger. ($p < 0.05$) It is worth noting that the emotion of disgust did not have significant correlation with any of the selected color characteristic factors.

Table 2. The correlation analysis between public basic emotions and color factors of flower borders.

Items [a]	Sadness	Neutral	Disgust	Anger	Surprise	Fear	Happiness
NPP	0.003	0.005	−0.004	−0.012	0.004	0.008	−0.011
PFPP	0.015	−0.013	−0.004	0.006	−0.006	−0.022 *	0.025 **
C1	0.010	−0.009	−0.006	0.019 *	−0.004	−0.006	0.005
C2	0.012	−0.015	−0.003	0.031 **	0.004	0.002	−0.008
C3	0.009	−0.018	−0.006	0.026 **	−0.004	0.022*	−0.001
C4	0.001	−0.006	−0.001	0.008	−0.008	0.000	0.013
C5	0.004	0.016	0.009	−0.022 *	0.024 **	0.012	−0.055 **
C6	−0.010	0.001	0.004	0.002	0.016	−0.010	−0.001
C7	−0.014	0.002	−0.003	−0.013	−0.020 *	−0.032 **	0.061 **
C8	−0.011	−0.001	−0.011	−0.004	−0.031 **	−0.021 *	0.063 **
C9	−0.019 *	0.005	−0.003	0.006	−0.020 *	−0.017	0.040 **
V1	−0.026 **	0.024 **	−0.002	0.021 *	0.014	−0.034 **	−0.015
V2	−0.022	0.019 *	0.011	−0.019 *	0.018	−0.006	−0.016
V3	0.014	−0.022 *	0.007	0.009	0.005	0.008	0.004
V4	0.028 **	−0.020 *	−0.009	−0.014	−0.027 **	0.029 **	0.022 *
S1	−0.013	−0.004	−0.001	−0.004	−0.023 **	−0.004	0.048 **
S2	−0.015	0.005	0.013	−0.017	0.013	−0.006	0.005
S3	−0.002	0.012	0.007	−0.011	0.014	−0.012	−0.021 *
S4	0.017	−0.010	−0.013	0.023 *	−0.008	0.014	−0.010

*, ** Significant at $p = 0.05$ or 0.01, respectively. [a] Same as Table 1.

3.2. Correlations between the Color Characteristics and Public Emotional Pleasure

The purpose of the reliability analysis is to investigate whether the sample data are true and reliable. The questionnaire data were imported into SPSS software for reliability analysis and the reliability statistic (Cronbach's Alpha = 0.911 > 0.801). Therefore, the results indicate that the internal consistency of public emotional pleasure scores is very good.

The public emotional pleasure for flower borders and the color factor data of the samples were obtained through a questionnaire survey and Python analysis, respectively. After organizing the data, it was input into SPSS software for analysis to calculate the public emotional pleasure score. Pearson correlation analysis was used to explore the relationship between public emotional pleasure and flower border color characteristics. The results of the correlation analysis are shown in Table 3. There was a significantly positive correlation between public emotional pleasure and the color factors C4, C7, C8, C9, S1, V1, V2, and NPP ($p < 0.01$, coefficients > 0). Conversely, C1, C5, S3, V3, V4, and PFPP had a significantly negative correlation with public emotional pleasure ($p < 0.01$, coefficients < 0).

Table 3. The correlation analysis between public emotional pleasure and color factors of flower borders.

Items [a]	Public Emotional Pleasure	
	Coefficients	**Significance**
NPP	0.092 **	<0.001
PFPP	−0.085 **	<0.001
C1	−0.035 **	0.004
C2	−0.002	0.850
C3	−0.030 *	0.014
C4	0.034 **	0.005
C5	−0.082 **	<0.001
C6	−0.027 *	0.028
C7	0.087 **	<0.001
C8	0.092 **	<0.001
C9	0.082 **	<0.001
V1	0.047 **	<0.001
V2	0.113 **	<0.001
V3	−0.045 **	<0.001
V4	−0.084 **	<0.001
S1	0.147 **	<0.001
S2	0.011	0.357
S3	−0.100 **	<0.001
S4	−0.001	0.936

*, ** Significant at $p = 0.05$ or 0.01, respectively. [a] Same as Table 1.

By comparing the results of Tables 2 and 3, we can see that although the color factors related to public emotions identified in each are different, there are many similarities. We believe that the color factors identified in Table 3 more accurately and comprehensively reflect the overall color of the flower borders. Therefore, we will use these factors for subsequent data analysis

3.3. Extraction of Color Characteristic Common Factors

All factors with significant ($p < 0.01$) correlations with public emotional pleasure were screened, and it was found that the correlation coefficient for V1 was low, indicating it had little effect on public emotional pleasure. Additionally, V1 was highly correlated with V4 (Figure S2). Among the commonly used plant materials for flower borders, low-value plants are seldom used because they make the overall color look dark, which may trigger negative emotions [48]. Therefore, only V2, V3, and V4 were selected as the brightness factors for predicting the color characteristic scores.

The KMO value is an index value to test whether the factor is suitable for factor analysis. In this study (KMO = 0.502 > 0.5, Bartlett's test Sig. = 0.000 < 0.001), the result

indicates that it is suitable for factor analysis. In this process, it was determined that four factors were extracted, which accounted for approximately 79.33% of the total data variance. The results of calculating the rotated factor loadings are shown in Figure 3.

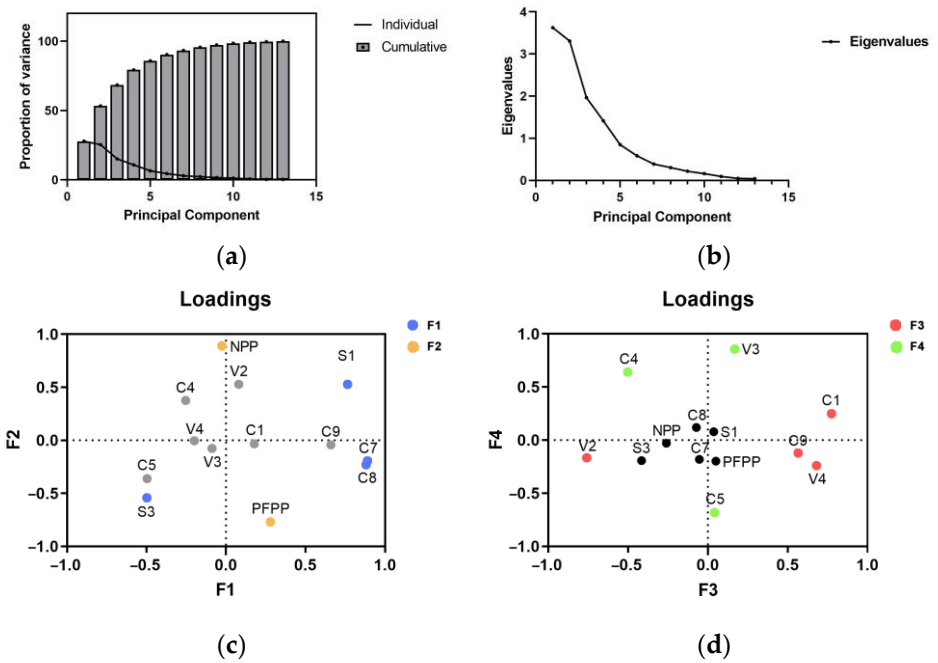


Figure 3. Factor analysis of flower border color characteristics. (**a**) The principal components' proportion of variance; (**b**), the principal components' eigenvalues; (**c**), F1, F2 factor loadings; (**d**), F3, F4 factor loadings.

Among the factors, F1 had the highest variance explanation amount (27.88%). F1 and F2 together explained 53.32% of the variance, indicating that these two factors most significantly influence the flower border color characteristics. F1 contained four factors: C7, C8, S1, and S3, with C7 and C8 having the highest factor loadings. This factor was specifically represented by the blue-violet color in the flower borders, so F1 was named the "low saturation of blue-violet percentage". In F2, the factor loadings of NPP and FPFF were relatively high, reflecting the distribution and richness of colors in the flower borders, thus F2 was named the "color configuration diversity". F3 contained four color factors: C1, C9, V2, and V4, which represented the brighter red colors in the flower borders, so F3 was called the "bright red percentage". F4 contained three color factors that were mainly green, so F4 was named the "base green percentage" (Table 4).

Table 4. Description of the common factors.

Factor	F1	F2	F3	F4
% of variance	27.88	25.44	15.11	10.89
Normalization	0.351	0.321	0.199	0.137
Description	low saturation of blue-violet percentage	color configuration diversity	bright red percentage	base green percentage

3.4. Construction of the Evaluation Model of Flower Border Color Characteristics Based on Public Emotional Pleasure

After performing the principal component analysis, we were able to obtain a matrix of coefficients for the color factor component scores based on the regression algorithm (Table 5).

Table 5. Matrix of coefficients for the score of the color factor components.

Items [a]	Coefficient of Component Score			
	1	**2**	**3**	**4**
NPP	−0.020	0.374	−0.001	−0.135
PFPP	0.116	−0.323	−0.092	−0.010
C1	−0.008	0.042	0.326	0.125
C4	−0.063	0.026	−0.175	0.330
C5	−0.138	−0.044	0.031	−0.332
C7	0.297	−0.101	−0.115	−0.087
C8	0.293	−0.163	−0.136	0.090
C9	0.167	0.045	0.201	−0.087
V2	0.069	0.162	−0.278	−0.150
V3	−0.050	−0.130	0.052	0.498
V4	−0.115	0.126	0.330	−0.151
S1	0.220	0.204	0.020	−0.040
S3	−0.102	−0.252	−0.212	−0.017

[a] Same as Table 1.

Based on the coefficients of component score corresponding to each color characteristic factor in the four common factors, expressions for the scores of the common factors F1, F2, F3, and F4 can be derived.

$$F1 = -0.020NPP + 0.116PFPP - 0.008C1 - 0.063C4 - 0.138C5 + 0.297C7 + 0.293C8 + 0.167C9 + 0.069V2 - 0.050V3 - 0.115V4 + 0.220S1 - 0.102S3 \quad (1)$$

$$F2 = 0.374NPP - 0.323PFPP + 0.402C1 + 0.026C4 - 0.044C5 - 0.101C7 - 0.163C8 + 0.045C9 + 0.162V2 - 0.130V3 + 0.126V4 + 0.204S1 - 0.252S3 \quad (2)$$

$$F3 = -0.001NPP - 0.092PFPP + 0.326C1 - 0.175C4 + 0.031C5 - 0.115C7 - 0.136C8 + 0.201C9 - 0.278V2 + 0.052V3 + 0.330V4 + 0.020S1 - 0.212S3 \quad (3)$$

$$F4 = -0.135NPP - 0.010PFPP + 0.125C1 + 0.330C4 - 0.332C5 - 0.087C7 + 0.090C8 - 0.087C9 - 0.150V2 + 0.498V3 - 0.151V4 - 0.040S1 - 0.017S3 \quad (4)$$

Since the relationship between the common factors representing the original variables is more conducive to reflecting the characteristics of the research object, we aimed to more accurately determine the influence of color characteristics. Using the variance contributions of the four common factors in Table 4, which were normalized as the weights of the common factors, we calculated the composite score F.

$$F = 0.351F1 + 0.321F2 + 0.199F3 + 0.137F4 \quad (5)$$

We then compared the F values calculated for each sample image with the public emotional pleasure scores for viewing them (Figure 4). It was found that the higher the F value, the more pleasant the flower borders were for viewers. Thus, we performed a linear fit based on Figure 4 to obtain an equation relating F to public mood pleasure ($R^2 = 0.544$, $p < 0.00001$).

$$y = 0.1539 \times x + 3.151 \quad (6)$$

In the validation experiments, we calculated the F-score and the public emotional pleasure score for each image. The results showed that flower borders with higher F-scores were also more enjoyable for viewers (Figure S4). This is consistent with our previous conclusions and also further demonstrates the reliability of F in predicting public emotional pleasure in viewing flower borders.

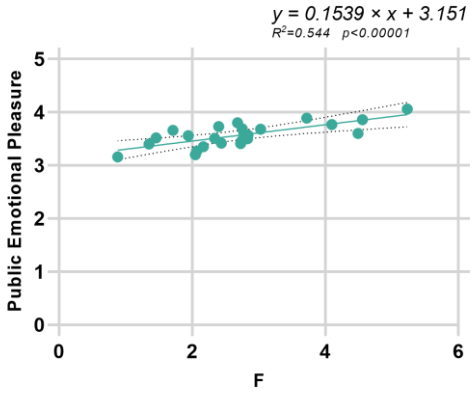


Figure 4. Relationship between public emotional pleasure and flower border color characteristics score F. (The dots in the figure are the data corresponding to each sample image, and the dashed lines indicates the 95% CI of the fitted line.)

4. Discussion

4.1. How Do Flower Border Colors Influence Public Emotions?

From the data in Table 2, we can clearly see the relationship between the flower border color factors and the seven basic emotions of the public. Through the analysis of these data, we find that there is a very strong connection between flower border colors and public emotions, which further proves that a good flower border color configuration can effectively promote the generation of positive public emotions. Specifically, the color factors PFPP, C5, C7, C8, C9, V4, S1, and S3 showed a significant correlation with happiness. Among them, PFPP, C7, C8, C9, V4, and S1 showed a significant positive correlation, indicating that these color factors can enhance the public's happiness. At the same time, these color factors showed varying degrees of negative correlation with other negative emotions, further confirming their role in reducing negative emotions. This means that adding low-saturation blue-violet plants to flower borders can significantly enhance the public's positive emotions when viewing them, effectively improve the public's emotional health, and enhance their feelings of well-being. This is likely due to the fact that cooler colors, such as blue-violet, tend to bring about positive mood changes and have a greater restorative effect. Blue-violet flowers are more effective in making people feel calm and relaxed, reducing anxiety, anger, and fatigue [49–51].

Although C5 is negatively correlated with happiness, this may be because green, as the dominant color in natural landscapes, is the most common plant color seen by the public in their daily lives. Therefore, when people see green in flower borders, it may not stimulate their happy emotions effectively. The prevalence of green makes its effect on stimulating happiness relatively weak. However, it is worth noting that C5 was positively correlated with surprise and negatively correlated with anger, suggesting that green can stimulate positive emotions and reduce negative emotions. This may be due to the calming and soothing effect of green as a natural color. When people see a lot of green plants in a flower border, although it may not make them feel extremely happy, it can bring a sense of relaxation and calmness, which can stimulate positive emotions such as surprise. At the same time, the presence of green helps to relieve stress and reduce negative emotions such as anger and anxiety, which is consistent with previous research [49,52,53]. At present, some of the flower borders have the problem of too low a proportion of green plants. The visual effect of the flower borders is weakened by the lack of evergreen trees and shrubs in the middle and upper layers, or by the yellowing of plants, resulting in fewer green plants. Flower border design should appropriately increase the proportion of green plants, and at the same time, should pay attention to the relationship between warm and cold of green plant leaf color, so that the proportion of warm and cold of the flower border tone color is more balanced.

4.2. The Color Configurations of Flower Borders as an Important Factor in Enhancing Public Emotional Pleasure

The correlation between each color factor of the flower border and the public emotional pleasure can be seen in Table 3. This indicates that the results can be used to guide the subsequent design of flower borders. Among all the color factors positively correlated with public emotional pleasure, S1 is the most highly correlated factor, which means that the higher the proportion of low-saturation colors in the flower borders, the more pleasant they are for people to view, and the significantly negative correlation between the public emotional pleasure and the S3 also proves this conclusion. This suggests that adding plants with low-saturation colors in the flower borders of urban green space can effectively increase the public pleasure. However, this is different from the results of previous studies [54], which concluded that the higher the saturation of plant color, the higher the preference for it. The reason for this discrepancy may be that the scale of the experimental material affects the public preference for color saturation. In large-scale landscapes, the color patches of plants are more dispersed, and highly saturated colors can make the plants more recognizable, creating more spectacular landscapes and giving the public a stronger visual impact. This can enhance the public's appreciation of the beauty of the planted landscapes and improve their mood. In small-scale landscapes, the colors of plants are more concentrated, and low-saturation colors can effectively reduce public fatigue, thus increasing their pleasure of the landscape. In design practice, we can increase the application of low-saturation plants, thus increasing the contrast of plant colors and perfecting the overall color sequence of the flower border and the creation of a sense of space so that the visual effect becomes soft and beautiful.

Color plays an important role in determining landscape preferences [55,56] and is an important tool for regulating, guiding, and inducing specific psychological states in individuals [57]. It is worth noting that C7, C8, and C9 were also positively correlated with the public emotional pleasure. These three factors are associated with blue-violet colors, indicating that a higher proportion of blue-violet colors in flower borders will be more pleasant for the public to view, thus increasing their preference for the landscape. A similar conclusion can be obtained in previous studies [46,58]. In contrast, studies on the color of individual woody plants and plant communities have shown that the percentage of plants with cool colors, such as blue-violet, is negatively correlated with aesthetic preference [59,60]. This may be because the color of herbaceous plants is often derived from their flowers, while the color of woody plants is often derived from their leaves. The public may be unfamiliar with cold-colored woody plants, leading to negative evaluations [60]. Many flower borders have the problem of excessive use of warm-colored plants and lack of cool-colored plants to balance the warmth and coolness of colors. The imbalance of the color ratio due to excessive warm-colored color blocks in the flower borders leads to a decrease in the public emotional pleasure. Therefore, during the design process of flower borders, it may be beneficial to increase the use of blue-violet plants to enhance public pleasure when viewing the landscape.

In our study, we similarly found that V1 and V2 are positively correlated with public emotional pleasure, while V3 and V4 are negatively correlated. This indicates that the public derives more pleasure from viewing medium brightness colors rather than high brightness colors. This is most likely because medium and low brightness colors make people feel safe [61], a conclusion also supported by previous studies [47,62]. These findings contribute to the design of flower borders with different landscape sites and landscape functional characteristics in urban green space to meet the emotional needs of the public.

4.3. The Relationship between Public Emotional Health and Color Characteristics of Flower Borders

In this study, we used factor analysis to extract four color characteristic common factors affecting public emotional pleasure with flower borders, namely, "low saturation of blue-violet percentage", "color configuration diversity", "bright red percentage", and "base green percentage". The factor explanation rate is 79.33%, indicating that the common factors

extracted in this study can better represent the main flower border color characteristics [63]. The selected color factors can more comprehensively explain the internal relationship of the color characteristics. Three of the common factors are related to color, so color configuration can be seen as a key variable in the design of flower borders. Color plays an important role in determining landscape preferences and is a vital tool for regulating, guiding, and inducing specific psychological states in individuals [55–57].

Among these four common factors, F1 has the greatest influence on the color characteristics, which is similar to the results of previous studies [46]. This suggests that an appropriate increase in the proportion of low-saturation blue-violet plants in the design of flower borders would be more effective in improving the public's emotional state. It is worth noting that the flower border, as a type of plant combination landscape, involves various plants working together. Increasing the proportion of low-saturation blue-violet does not mean using only this color. In practice, the proportion of such plants should be adjusted rather than exclusively using them. F2 also significantly influences the flower border color characteristics, suggesting that to provide more pleasure to the public when viewing them, a relatively rich color configuration pattern should be chosen [34,46]. In the practice of designing flower borders, we can appropriately increase the number of plant patches and flowering plants and try to adopt small plant patches interlaced to form a changeable and rhythmic color distribution.

In addition, the evaluation model for the flower border color characteristics was constructed based on these four common factors, providing a new method for predicting public pleasure while viewing flower borders, enabling them to better enhance the public's emotional state. Good color design can effectively improve the quality of flower borders, but each color characteristic common factor is not independent in shaping the visual effect. In future design practice, we can focus on the four common factors of color characteristics extracted from this study to improve the quality of flower borders. Although it may be challenging to consider all aspects in the design process, designers should be flexible and make adjustments according to specific geographic conditions and environmental needs, making appropriate choices to meet the real situation and design objectives.

4.4. Future Perspectives

There are still several limitations that need to be considered in future studies. In the real world, landscape perception is usually considered a dynamic process. The method used in this experiment of replacing the actual landscape with photographs, although effective, could not provide subjects with more spatial experience, and all the experimental materials could only be presented in 2D, which is still sensory different compared with the actual. The development of VR technology offers new ideas and methods for simulation research in the field of landscapes [64]. Future research can utilize more realistic and accurate experimental materials to overcome the temporal and spatial constraints and uncertainties of the experiment. In addition, this experiment focused only on the color characteristics of the flower border. However, spatial characteristics such as plant morphology and spatial distribution are also important factors affecting the quality of flower borders, and the present experiment is still not comprehensive enough in this regard. In reality, color presentation is usually interrelated with other features. Future research can build on existing color studies and combine them with spatial features to explore new modes of flower border design, thereby better improving the quality of flower borders. Finally, our experiment only collected changes in participants' facial expressions while viewing the stimulus images. Future research can incorporate physiological experimental methods to broaden the scope of the experiment, such as eye tracking, nuclear magnetic resonance, and others, can be used to more comprehensively understand the physiological and psychological changes from multiple dimensions, making the findings more convincing.

5. Conclusions

With the increasing emphasis on well-designed urban environments, flower borders, as an exquisite form of plant application in urban green space, play a significant role in enhancing public emotional health. In this study, 24 sample images were used as experimental materials to explore the relationship between the flower border color characteristics and public emotional health through online random questionnaires and facial recognition technology. The results show that the appropriate color configuration of flower borders can not only satisfy the public's aesthetic needs but also stimulate positive emotional responses during viewing. Through factor analysis, we extracted four common factors of flower border color characteristics related to public emotional pleasure: "low saturation of blue-violet percentage", "color configuration diversity", "bright red percentage", and "base green percentage". The similarity of these findings with previous studies further validates the important role of color in landscape design. An evaluation model of color characteristics was constructed based on the variance explained by these four factors, demonstrating its usefulness for predicting the level of public emotional pleasure when viewing flower borders. This provides a new perspective for assessing and measuring the effectiveness of future flower border designs. These findings not only enrich the theoretical research on flower border design but also provide concrete and feasible guidelines for designers in practice, helping them create urban green space that are both aesthetically pleasing and beneficial for mental health. Through such designs, we can expect to see more creative and enjoyable flower borders in future urban environments, providing the public with a better living experience.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/f15101688/s1, Figure S1: Questionnaire 1. Public Emotional Pleasure Scale for Flower Borders (Imagine that you are in the scene presented in the image and assess how happy you feel when you look at the flower border by ticking the items you choose, where 5 = very happy and 1 = very unhappy); Figure S2: Color Factor Correlation Heat Map; Figure S3: 10 domestic and international flower borders used in the validation test; Figure S4: Relationship between public emotional pleasure and flower border color characteristics score F in a validation test.

Author Contributions: Conceptualization, Z.W., X.S. and Y.X.; Methodology, X.S.; Software, Z.W.; Validation, Z.W., X.S. and Y.C.; Formal analysis, Z.W. and Y.C.; Investigation, X.S. and Y.C.; Resources, Y.S.; Data curation, Z.W. and X.S.; Writing—original draft, Z.W.; Writing—review & editing, Z.R.; Visualization, Z.W. and Z.R.; Supervision, Y.X.; Project administration, Y.S.; Funding acquisition, Y.X. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data presented in this study are available on request from the corresponding author due to the ongoing research, and the authors will continue to work with it in the future.

Conflicts of Interest: Author Yang Su was employed by the company The Architectural Design & Research Institute of Zhejiang University Co., Ltd. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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