The Effect of Background Color on Facial Emotion Recognition

Longyue Qin

Faculty of Psychology, Southwest University, Chongqing, China

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Abstract: This experiment aims to further understand the influence of color on emotion recognition, and to understand the influence of warm and cool colors and neutral colors on emotion recognition judgment. This experiment is a mixed experiment design of 3 (background colors) × 3 (emotional face picture types), with the background colors (cool/warm/white) as the inter-subject variables, and the emotional face picture types (positive/negative/neutral) as the intra-subject variables. The dependent variables are the Likert 5-point rating scores and the subjective evaluation scores of the colors given by subjects. The experimental results show that whether it is a positive emotional face, a neutral emotional face or a negative emotional face, the scores of the warm-color background group and the cool-color background group are significantly different. The scores of the cool-color background group and the white background group are significantly different. The warm-color background group and the white background group have significant differences in scores. The average score of the warm-color background group is greater than the average score of the neutral background group than the average score of the cool-color background group. The background color has an influence on facial emotion recognition. Compared with cool tones and neutral tones, individuals in warm tones are more inclined to make pleasant judgments. Warm colors are usually used as emotional clues to express warmth and happiness; cool colors are usually used as emotional clues to express cool or calm; neutral colors are usually used as emotional clues to express peace.

1. Introduction

Whether color has a certain effect on mental function has attracted the attention of many psychologists. The effect of color on human cognitive processing and emotion is an important part of the psychological research on color [1]. Goldstein (1942) proposed that humans have an inherent physiological response to color. In terms of the impact on psychological experience and function, Goldstein believes that red and yellow give people a sense of irritation and disgust, and guide individuals to pay attention to the external environment; green and blue give people a sense of tranquility and pleasure, and guide individuals to pay attention to the inner world.

We live in a world of colorful colors. Colors have emotional meanings and affect individual psychological functions [2]. Classical color vision theory makes people more inclined to divide colors into cool colors and warm colors. Red with longer wavelengths is warm, and blue with short wavelengths is cool. Cool and warm colors also cause different physiological changes in people. Cool colors make people quiet, warm colors make people excited. Red, orange, and yellow are used as “warm colors”, which are usually used as emotional cues to express enthusiasm, warmth and happiness; “cool colors” represented by blue-green and purple, are usually used as emotional cues to express cool, depressed or calm. [3].

In psychology, the research of color as a stimulus target and as an “environmental/background” factor has gradually emerged, such as indoor and factory environment. Nancy J. Stone (1998; 2003) studied the influence of mood, satisfaction and work performance in completing related work tasks under the color environment of the workplace, and studied the cool color (blue) and warm color (red) 's impact on job performance in the simulated remote sales activities.

Face emotions, as one of the main ways to understand the emotions of others, are of great significance for individuals to carry out normal social interactions [4]. At present, researchers have begun to pay attention to the influence of colors with emotional cues on facial emotion recognition,

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but there are relatively few studies on the influence of warm and cool tones on facial emotion recognition, which needs to be further deepened. In order to further understand the influence of color on emotion recognition, and to understand the influence of warm, cool and neutral colors on emotion recognition judgment, this experiment is a mixed experiment design of 3 (background colors) × 3 (emotional face image types), with the background colors (cool/warm/white) as the inter-subject variables, and the emotional face picture types (positive/negative/neutral) as the intra-subject variables. The dependent variables are the Likert 5-point rating scores and the subjective evaluation scores of the colors given by subjects. On the one hand, the research goal is to supplement and expand the previous experiments on facial recognition related to emotions, on the other hand, it is to enrich experiments related to face recognition and emotional experience. According to previous studies, the experimental results are predicted: in warm tones, individuals recognize facial emotions as pleasant and are more inclined to make pleasant judgments; in cool colors, individuals recognize facial emotions as unpleasant and more tend to make negative judgments; on a white background, compared with warm and cool tones, it has no obvious effect on emotional face recognition.

2. The Experiment

2.1 Method

2.1.1 Testees

45 subjects were randomly recruited, the average age was 19.3, the age range was 15-26, and the male to female ratio was 22:23. Subjects have normal intelligence, normal vision, no color blindness, and a good experimental attitude. The selected data were all valid data.

2.1.2 Instruments and Materials

The experimental materials include neutral/positive/negative emotional faces and background colors. The experiment selected 18 neutral/positive/negative emotional faces from the International Emotional Picture System (IAPS), 9 male and female faces each, and 54 emotional face materials in total. All picture pixels are 376 × 288, with uniform brightness and contrast. The experimental program is compiled by E-Prime 2.0 software, with a resolution of 1024 × 768. The background colors are red, yellow, white, green and blue (generated by E-Prime 2.0).

2.1.3 Procedure

Subjects sat 60cm in front of the computer with their eyes looking at the center of the computer. Subjects were randomly divided into 3 groups: a warm-color background group, a white background group, and a cool background group. Each background group had two rounds of testing. The background color of the first round of the warm-color background group was red, and the background color of the second round was yellow; the background color of the first round of the cool-color background group was green, and the background color of the second round was blue; the background color of the two rounds of the white background group was white.

The examiner instructs the subjects to enter their number, gender, age and other information. After the input is completed, the examiner presses the enter key to enter the instruction interface. The examiner explained to the subjects with the instruction to help them understand the Likert 7-point rating (1 = very negative; 3 = neutral, neither positive nor negative; 5 = very positive). After the subjects finished reading the instruction, they pressed the space bar to start the experiment. At the center of the screen, a 1000ms black gaze cue “+” was first displayed, and then 27 pictures of emotional faces from the first round were randomly presented (9 positive emotional pictures, 9 pictures). Neutral emotion pictures, 9 negative emotion pictures), the color background occupied the entire screen, and the face picture was in the center of the color background. Subjects rated 27 pictures from 1 to 5 points. After completion, the rest words with white as the background color are displayed in the center of the screen for 30 seconds. After the rest, proceeding to the second round of experiment, presenting the instruction again, pressing the space bar to start the second round of

experiment, except that the background color was different from the emotional face picture, the experiment process was basically the same as the first round of experiment.

After completing the two rounds of trials, the examiner instructed the subjects to fill in the subjective color emotional meaning questionnaire, using a 5-point scale (1 = very unpleasant; 3 = neutral; 5 = very pleasant) to enjoy the five colors of red, yellow, white, green and blue degree evaluation.

The examiner organized and counted the scores of the subjects on the same picture under the influence of different background colors and the subjects' subjective judgment of a certain color as pleasant scores, and conducted data analysis.

2.2 Result

Descriptive statistics were performed on the score data of different emotional face pictures for 45 subjects under different background colors, and the results are shown in Table 1. Under a positive face, compared to cool tones (M = 2.47, SD = .59) and neutral tones (M = 2.73, SD = .28), when the background is warm (M = 4.15, SD = .76), the score of recognizing facial emotions as pleasant is higher. Under a neutral face, compared to cool tones (M = 2.57, SD = .59) and neutral tones (M = 2.81, SD = .23), when the background is warm (M = 3.8, SD = .86), the score of recognizing the facial emotions as pleasant is higher. In a negative face, compared to cool tones (M= 2.20, SD = .25) and neutral tones (M= 2.78, SD = .15), when the background is warm (M = 4.16, SD = .24), The score of recognizing facial emotions as pleasant is higher. From the point of view of the average value, whether it is a positive emotional face, a negative emotional face or a neutral emotional face, the average value under the warm color background is greater than the average value in the neutral color background than the average value in the cool background.

Table 1 Descriptive statistics results

Picture type	Background color	Sample capacity (n)	Standard deviation (sd)	Mean (m)
Positive face	Warm tones	15	0.76	4.15
	Neutral color	15	0.28	2.73
	Cool tones	15	0.59	2.47
Neutral face	Warm tones	15	0.86	3.80
	Neutral color	15	0.23	2.81
	Cool tones	15	0.59	2.57
Negative face	Warm tones	15	0.24	4.16
	Neutral color	15	0.15	2.78
	Cool tones	15	0.25	2.20

The examiner used the background color as the inter-group variable, and the picture type as the intra-group variable. Repeated-measure analysis of variance was performed on the scores of emotion recognition of different types of faces. It was found that the main effect of the background color is extremely significant (F=107.836, P=.000<.01). The main effect test result of neutral pictures: F=5.071, P.011<.05, indicating that the main effect of neutral pictures is significant; the main effect test result of positive pictures: F=.826, P=.445>.05, showing that the main effect of positive pictures is not significant; the main effect test result of negative pictures: F=2.202, P=.123>.05, showing that the main effect of negative pictures is not significant. The main effect of picture type is not significant (F=0.242, P=0.786>0.05). The interaction between picture type and background color is not significant (F=2.469, P=.051>.05).

A one-sample t-test with the positive facial emotion recognition result (M = 2.73) under a neutral color (white) background found that the happiness rating score under a warm color background is significantly higher than that under a neutral color background, t (14) =7.203, P= .000<.01, Cohen' sd = 1.86; There is no significant difference in the pleasant rating score between the cool color background and the neutral color background t (14) = -1.712, P=.109>.05, Cohen' sd = -. 44. This also shows that the background color has different effects on the emotion recognition of positive faces by individuals.

A single-sample t-test with the neutral face emotion recognition result (M = 2.81) under a neutral color (white) background found that the happiness rating score under a warm color background is significantly higher than that under a neutral color background, t (14) =4.492, P = .001<.01, Cohen'

sd =1.16; There is no significant difference in the pleasant rating score between the cool color background and the neutral color background, t (14) = -1.559, P=.141>.05, Cohen' sd = -.403. This also shows that the background color has different effects on individual emotion recognition of neutral faces.

A one-sample t-test with the negative facial emotion recognition result (M = 2.78) on a neutral color (white) background found that the happiness rating score on a warm color background is significantly higher than that on a neutral color background, t (14) =22.070, P= .000<.01, Cohen' sd = 5.698; the pleasant rating score under the cool background is significantly lower than the neutral background, t (14) = -9.113, P=.000<.01, Cohen' sd = -2.353. This also shows that the background color has different effects on the emotion recognition of negative faces by individuals.

A five-point rating of the emotional meaning of colors (1 = very unpleasant; 3 = neutral; 5 = very pleasant) found that there is a significant difference in the pleasant scores of cool and warm colors, F (1, 43) = 7.36, P = .01, ηp 2 = .33; the pleasant degree of cool colors represented by blue (M = 3.35, SD = 1.056) is significantly lower than warm colors represented by red (M = 4.20, SD = .978). The one-sample t-test subjective evaluation results and the test value 3 found that there is no difference in the degree of pleasant degree of cool colors, t (89) = 1.116, P= .268>.05, Cohen' sd = .117; warm colors' pleasant degree is significantly higher than the random level 3, t (89) = 5.868, P = .000<.01, Cohen' sd = .618. This shows that warm colors have a higher level of pleasant rating than cool colors, and cool colors have a more peaceful emotional meaning.

The experiment program recorded the subjects' reactions to emotion recognition of face pictures under different background colors. With the background color as the inter-group variables, and the picture type as the intra-group variables, repeated measures analysis of variance was performed when responding to emotion recognition of different types of faces. It turns out that the main effect of the background color is not significant. The main effect of picture type is significant, F=5.293, P=0.009 (<0.05). In different picture types, the reaction time of cool-toned face recognition is the shortest, the reaction speed is faster, and the reaction time of neutral-toned face recognition is the longest. The recognition speed of negative faces is significantly lower than that of positive faces and neutral faces. Compared with neutral faces and negative faces, positive face emotion recognition is the fastest. Research shows that the background color has no significant effect on the speed of facial emotion recognition. The effect of background color on facial emotion recognition has time consistency. At 100ms, 500ms and 1250ms, the background color will affect the emotion recognition of neutral faces.

3. Discussion

This research aims to investigate the influence of warm-color and cool-color backgrounds on emotion recognition of faces with different emotions. The result shows that background color affects the individual’s emotional recognition of faces. Compared with the cool-color background represented by blue and the neutral color represented by white, under the warm-color background represented by red, individuals recognize more face emotions as pleasant, and they are more inclined to make pleasant judgments. The subjective evaluation results of the degree of emotional well-being of cool and warm colors also provide more explicit evidence for this.

This confirms the previous conclusion that the color background will affect facial emotion recognition: Color has emotional meaning and affects emotional processing of faces (赵月等,2015; Frühholz et al., 2011; Gil & Le Bigot, 2014, 2015; Palmer et al., 2013; Young et al., 2013). The individual under the color background will perceive the background color through the visual perception of the body, which reminds the individual of the corresponding emotional concept. The orange background evokes excitement and pleasant experience, and the blue background evokes peace, melancholy or sadness. It affects the individual’s emotional recognition of neutral faces [3].

The main effect of background color is significant and may be affected by multiple aspects. Personal color preference, cultural and traditional factors, etc. all have a certain impact on the emotional meaning of colors. The research of Huang Xiting et al. [3] shows that “the color

sentiment of most people in China is: red-excitement, joy, orange-pleasure, excitement, yellow-pleasure, comfort, green-comfort, pleasure, blue- -Calm, comfortable, purple-disgust, hesitation, black-sorrow, disgust, fear". The influence of color background on cognitive tasks has cultural differences. For Chinese, the influence of red and blue backgrounds on cognitive processing is not due to different motivations but different emotions [5]. Among them, the two warm colors (red and yellow) used in this experiment are more likely to be considered happy and joyful under the Chinese social and cultural background. Therefore, the scores of subjects in the warm color group are more likely to be higher compared with the scores of the neutral color background group. The two cool colors (green and blue) used in this experiment are more likely to be considered comfortable and quiet under the Chinese social and cultural background. Therefore, the scores of the cool-color group are more likely to be lower than the scores of the neutral color background group.

There are still controversies about the psychological mechanism of color affecting cognitive processing. Some experts Mehta and Zhu (2009, Science) believe that color affects the performance of cognitive processing by stimulating different motivations. Specifically, red is often associated with dangers and mistakes, which can stimulate avoidance motivation, thereby improving the performance of tasks that require concentrated attention; on the contrary, blue is often associated with openness and peace, which can cause tendency motivation, thereby improving the performance of creative tasks. However, some researchers believe that colors affect cognitive tasks by stimulating different emotions. The blue background is conducive to the processing of creative tasks, and the red background is conducive to the processing of general cognitive tasks. Other researchers believe that color association is a connection formed by acquired learning, and will enter a deep psychological tendency [5]. Starting from babies, people have encountered clear or subtle color and information pairing relationships. After repeated repetitions, a firm association is formed. Once a certain color is perceived, the pairing information will be automatically activated, thereby affecting mood, cognition and behavior. [2].

3.1 Deficiency

As far as the experimental materials are concerned, the main effect of picture types is not significant. On the one hand, it may be because the selection of face pictures is not accurate enough. The subjects also reported that subjectively it is difficult to judge emotions for some face pictures. In the future, more stringent material screening should be carried out in the production of experimental materials.

As far as the subjects are concerned, the age of the subjects is concentrated (M=19.4, SD=1.86), and the population with a larger age span is not measured. There are differences in the cognitive level of people of different ages, which may interfere with the experimental results.

The face emotion pictures used in this experiment are a group, so some face emotion pictures may be the face emotion pictures of the same person in two different emotions. This experiment has a small number of experimental groups. Except for the neutral color group, the background colors of the two rounds of the experiment are different between the warm-color background group and the cool-color background group, the subjects can take the scores in the first round as a reference to optimize the score in the second round. This experiment only analyzes the contrast between warm colors, white, and cool colors, and does not specifically analyze the difference between red and yellow under warm colors and green and blue scores under cool colors. The score difference between different colors is worthy of further study.

The controversy in previous studies is related to the inconsistency of experimental materials and procedures. The nature, difficulty, and time limit of the cognitive tests used in each study are different. The colors are presented in a variety of ways, the central fixation point or the peripheral background is presented, followed by time or at the same time. Presenting colors as the background of the test content at the same time may produce different visibility of color matching. In addition to hue, the brightness and saturation of colors should also be the subjects of research. In future research, it is possible to select interpersonal perception indicators that are closer to real life and

social interaction, so as to extend the basic research of facial emotion recognition to more real interpersonal situations.

4. Conclusion and Outlook

The background color has an influence on facial emotion recognition. Compared with cool tones and neutral tones, individuals in warm tones are more inclined to make pleasant judgments. Warm colors are usually used as emotional clues to express warmth and happiness; cool colors are usually used as emotional clues to express cold or calm; neutral colors are usually used as emotional clues to express peace. The background color has an impact on the emotion recognition of different types of faces. The emotional meaning of color is widespread, which will affect the individual's emotional cognition.

This research only focuses on simple cognitive tasks of emotion judgment in the background of cool and warm colors, and has no further cognitive requirements. A large number of previous empirical studies have compared the different effects of red and blue (or green, white) on cognitive task performance, but they have not yielded consistent research results. In addition, in future research, in order to further enhance the application value, richer color context manipulation can be performed, such as the color of clothes and accessories.

In this experiment, there is no gender difference in emotion judgments under different tonal backgrounds, which is consistent with the conclusion that there is no gender difference in emotion judgments of neutral faces in previous studies [7]. However, some studies have found that women have stronger emotional responses than men when they judge stimuli. [6] [8] Future research can further explore the influence of gender on color emotion recognition.

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