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Research Article

Numerical Analysis on Color Preference and Visual Comfort from Eye Tracking Technique

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Color preferences in engineering are very important, and there exists relationship between color preference and visual comfort. In this study, there are thirty university students who participated in the experiment, supplemented by pre- and posttest questionnaires, which lasted about an hour. The main purpose of this study is to explore the visual effects of different color assignment with subjective color preferences via eye tracking technology. Eye-movement data through a nonlinear analysis detect slight differences in color preferences and visual comfort, suggesting effective physiological indicators as extensive future research discussed. Results found that the average pupil size of eye-movement indicators can effectively reflect the differences of color preferences and visual comfort. This study more confirmed that the subjective feeling will make people have misjudgment.

1. Introduction

Color is an important factor in the physical environment for everyone. Children are attracted by bright and warm colors. As the child matures, color preferences change from their various experience or environment [1, 2]. Some colors may represent specific awareness, for example, blue: relaxation, calmness; red: love, romance; purple: calmness, laughing; green: nature, comfort. Different colorful learning environments improve visual processing, reduce stress, and enrich development of brain. Visual stimulation exactly fostered visual thinking, problem solving, and creativity [2]. Most of color preference researches used subjective assessment methods, such as survey or self-report [3]. Some studies showed that color preference could collect objective data via eye tracking technique [4, 5]. Hess and Polt (1960) had found that color preference seems to be related to one's pupils dilation, so this study would identify participants' color preference via pupil size [6]. Based on the eye-mind hypothesis, Just and Carpenter (1980) concluded that the eye tracking method can reveal the temporal change of visual attention that may further reflect how learners approach and process learning information [7]. The direction of gazing seems to be the same as direction of individual attention [8]. In addition, the researchers suggested that the relevant experiments reasoned that pupil diameter may correlate closely with control state and associated changes in behavior [9]. For these reasons, this study assumed that color preference will affect their viewing behaviors; at the same time, different colors will affect viewers' visual comfort. So, this study questioned that when people like certain color, does this mean that this color makes them feel comfortable? Based on this question, this study will adopt eye tracking technique to explore relationship between color preference and visual comfort.

2. Methods

2.1. Participants. There were thirty university students who participated in this study (mean age = 21). In order to confirm their color preference, they need to conduct the pretest. This study collected four types of color preferences students, including black, blue, green, and white. Before the eye

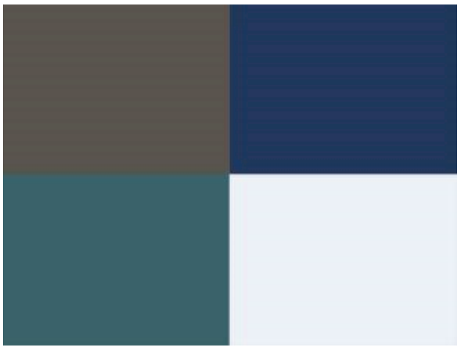

Figure 1: The sample of stimulus in the screen and it includes four blocks with black, blue, green, and white color.

tracking experiment, all of them passed the calibration test and then completed the experiment. However, four students' eye-movement data were eliminated because of drifting of eye movement. Sequentially, each student completed the posttest to identify the visual comfort about stimulus in this study. So, all of them participated in the eye tracking experiment, supplemented by pre- and posttest questionnaires, which lasted about an hour.

2.2. Apparatus. This study adopted eye tracker to record the participants' eye-movement data. The eye tracking system included two monitors and one infrared camera. One monitor (SAMSUNG 920N) was used for presenting video to learners, and the other monitor (SAMSUNG 9438) was used for researchers to control the experiment. The monitor resolution setting was 1024 × 768 pixels, and the refresh rate was 75 Hz. The eye movement sample rate was 60 Hz. The data were collected by using the SMI Experiment Center program in the experiment.

2.3. Stimulus. In this study, participants need to complete eye tracking experiment. During the experiment period, they had to view the stimulus in the screen. The experimental materials included 24 pictures generated by four colors. Figure 1 displayed the sample of stimulus in the screen. The display of each picture in the screen is divided into four sections, and each section fills in one color, as black, blue, green, and white. Moreover, four colors randomly generated different positions of color assignment. In this way, 24 pictures would be different from each other.

2.4. Data Collection and Analysis. In this study, eye tracking system mainly collected eye-movement data while participants viewed the stimulus in the screen. Four participants' eye-movement data were eliminated because of drifting of eye movement. Twenty-six students' eye-movement data were further analyzed. The relevant numerical data included various eye-movement indicators, for example, fixation, saccade, blink, and pupil size. In order to identify the relationship between color preference and visual comfort, this study will analyze the specific indicator, that is, average pupil size (APS). APS means the average size of pupil diameter. In this way, this study could assess the effectiveness of APS in identifying color preference or visual comfort. All quantitative data were measured by statistical software SPSS. The numerical data would be examined by statistical test, so that we could find the significant differences between various groups.

Table 1: The ANOVA summary of APS among 4 colors for color preferences.

Preference	AOI	APS		*F*	
		Mean	SD	Preference	Interaction
Black (N = 4)	Black	15.83	1.28	1.357	1.039
	Blue	15.84	1.32		
	Green	15.93	1.35		
	White	15.32	1.29		
Blue (N = 11)	Black	14.74	0.77		
	Blue	14.97	0.79		
	Green	14.92	0.81		
	White	14.40	0.78		
Green (N = 7)	Black	13.03	0.96		
	Blue	13.20	0.99		
	Green	13.51	1.02		
	White	12.99	0.98		
White (N = 4)	Black	12.78	1.28		
	Blue	12.75	1.32		
	Green	13.30	1.35		
	White	12.40	1.29		

3. Results and Discussion

3.1. APS Differences for Color Preference. According to the pretest questionnaire, twenty-six participants were distinguished into four color preference groups, including 4 black color, 11 blue color, 7 green color, and 4 white color preference. In addition, researcher defined the four areas of interest (AOIs): black, blue, green, and white area. We separately computed the average pupil size on four AOIs of screen and examined the significant difference among each group by repeated measures ANOVA. In this way, this study calculated APS (pixel) on different AOIs for 4 color preference groups. Table 1 showed mean and SD of different color preference groups on 4 AOIs. According the statistical test, the result showed that there is no significant difference on color preference ($F = 1.357$, $P = 0.282$) and there is also no interaction between color preference and AOIs ($F = 1.039$, $P = 0.419$). It means that color preference does not affect APS on different AOIs. In other words, the physiological response of APS did not change because of specific color preference.

3.2. APS Differences for Visual Comfort. According to the posttest questionnaire, twenty-six participants were distinguished into four visual comfort groups; it means what color makes students feel visually comfortable. This study found that 6 students felt that black color makes them visually comfortable, 4 students felt blue color, 6 students felt green color, and 10 students felt white color. In addition, we separately

Table 2: The ANOVA summary of APS among 4 colors for visual comfort.

Comfort	AOI	APS		F	
		Mean	SD	Comfort	Interaction
Black ($N = 6$)	Black	14.97	1.38	0.473	1.826
	Blue	15.46	1.40		
	Green	15.96	1.38		
	White	15.17	1.36		
Blue ($N = 4$)	Black	14.08	1.96		
	Blue	14.54	1.99		
	Green	14.64	1.96		
	White	13.72	1.92		
Green ($N = 6$)	Black	14.57	1.04		
	Blue	14.68	1.06		
	Green	14.73	1.04		
	White	14.10	1.02		
White ($N = 10$)	Black	13.67	0.76		
	Blue	13.68	0.78		
	Green	13.79	0.76		
	White	13.33	0.75		

Table 3: The ANOVA summary of APS among 4 colors.

AOI	APS		F	Post hoc
	Mean	SD		
Black	14.09	0.54	13.91^{***}	Black < green
Blue	14.19	0.56		Black > white
Green	14.41	0.58		Blue < green
White	13.78	0.55		Blue > white Green > white

Note: $^{***}P < 0.001$.

computed the APS on four AOIs of screen and examined the significant difference among each visual comfort group by repeated measures ANOVA. Table 2 showed that there is no significant difference in visual comfort ($F = 0.473$, $P = 0.704$), and there is also no interaction between visual comfort and AOIs ($F = 1.826$, $P = 0.080$). This result means that visual comfort does not affect APS on different AOIs. That is, APS did not also change because of their feeling of visual comfort. Hence, this study found that the subjective color preference and visual comfort were just generated from individual psychological feeling. Although people thought the specific color lets them like or feel visually comfortable, their physiological response may not reflect their real thinking. Therefore, in order to further confirm this opinion, this study would separately compute the APS of all participants on these four AOIs and examine the difference of APS by ANOVA.

Sequentially, this study further measured the difference among four AOIs for all of 26 participants. Table 3 showed that there is significant difference among 4 AOIs ($F = 13.91$, $P < 0.001$, $\eta^2 = 0.387$). This result strongly displayed that people mainly were affected by different colors immediately. Moreover, this study found that APS of green color was significantly larger than the other colors, and the APS of white color is the smallest. This study also compared the questionnaire data and interview protocol to explore the reason. Most of them said that white color makes their vision comfortable. However, Table 3 showed that APS of white color was significantly smaller than other colors, and the APS of green color was significantly larger than another color. Based on the literature, the larger pupil size reflected comfortable feeling. So, the result exactly represented that the subjective feeling does not fit the real psychological response.

4. Conclusion

Based on the results, students in this study had different color preference and they had individual feeling on different colors. Most of the people said that white color made their visual vision comfortable; however, their eyes did not have the corresponding reaction. In other words, they felt specific color makes them comfortable while they were looking at something, but their objective physiological response would react naturally. This real reaction of eyes would help researchers investigate the relationship between the mental feeling and physiological feedback. To sum up, this study more confirmed that the subjective feeling will make people have misjudgment. This study proves that physiological feedback is not easily changed with color preference or visual comfort. In the future, this study should analyze another eye-movement indicator and try another method of numerical analysis. We believe these discussions can make us gain more insight on color preference and visual comfort via eye tracking technique.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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