

## An Experimental Study on Task Performance in Office Environment Applied with Achromatic and Chromatic Color Scheme

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### ABSTRACT

The purpose of this study is to explore the differences between achromatic and chromatic schemes in task performance. To investigate only the hue effect on the participants' performance, it was important to use the colors with the same value (lightness) on the surfaces of achromatic and chromatic scheme. The participants were sixty office workers who are academic and administrative staff from different departments of Bilkent University in Ankara. The study was carried out in an office room at the Department of Interior Architecture and Environmental Design at Bilkent University. In the first stage of the experiment participants were tested for color vision deficiencies and after a few minutes of adaptation, they were given performance tasks. Later, the participants evaluated the task they performed (self-report of the task) in 5 point scale likert-type questions. In the second stage, the same procedure was followed for the other color scheme (achromatic or chromatic). It was found that participants' performances were better in the chromatic scheme than their performance in the achromatic scheme, in addition it was found that there was no significant difference between achromatic and chromatic color scheme in terms of self-report of the tasks.

Keywords: office environment, color scheme, task performance.

### 1. INTRODUCTION

Office buildings are the most common work environments among others and many individuals spend nearly one-third of their lives at offices. It has been demonstrated that the physical environment of an office has impacts on variables such as employees' health, comfort, satisfaction, performance and social relations [1]. According to Vischer to improve the quality of working life, the physical environment and the users who occupy it must be considered together as a whole [2]. Color is considered as one of the environmental aspects of workspaces that may affect the performance. One of the studies related to this issue has been conducted by Ainsworth, Simpson & Cassell about the effects of red, green and white office interior colors on participants' mood and performance. The given task was to type words and the work performance was measured by typing errors and the ratio of errors to words typed. They found no significant performance difference between the groups and suggested that this was because of the short-term measurement of the performance [3]. The other study was by Kwallek & Lewis was designed to assess the effects of

red, green and white office environments on workers' productivity and mood. Participants performed a proofreading test in three settings. The results indicated that participants in the white office made significantly more errors than the participants in the red office [4]. Another study by Küller, Mikellides & Janssens has examined the relation between color, arousal and performance. They found that red color and patterns in the interior space put the brain in a more excited state and introverted persons, who are also in a negative mood became more affected by the environmental stimulus than others became, which caused severe changes in their performance [5]. This study aims to understand whether there are differences between achromatic and chromatic color schemes of an office environment in terms of task performance and also self-report of the task. In this study, it was crucial to use the colors with the same value (lightness) on the surfaces of achromatic and chromatic schemes to understand only the effect of hue on the task performance and self-report of the task.

## 2. EXPERIMENT

### 2.1. Experimental Set-up

The study was carried out in an office room at Department of Interior Architecture and Environmental Design, at Bilkent University in Ankara. The room measures were 4 x 4.10m, which makes 16, 4m<sup>2</sup> and ceiling height is 3.20m. The windows of the room were covered with thick and black insulating material preventing the penetration of daylight to control its effect on the perception of the room. The existing general direct (downward) lighting by the luminaries of recessed troffer with parabolic louvers was used as artificial lighting of the experiment. All of the wall surfaces and the ceiling were painted in matte white and the floor is covered with a pale pink-blue carpet. The existing light sources of the experiment room were changed according to the technical requirements (Table 1).

Light source:	Four Philips fluorescent lamps (TL-D 36W 840)
Color temperature:	4000K
Color rendering :	85 Ra
Illuminance level on the working surface:	400lux

Table 1. Specifications of the artificial lighting of the experiment room

The experiment room was redesigned according to the purposes of the study. Achromatic and chromatic color schemes were applied by painting the surfaces and using fabric coverings on the furnishing and the floor. Firstly, all of the wall surfaces were painted with gray color of the achromatic scheme. Then, plywood sliding panel system was constructed on two sides of the room to achieve flexibility in applying color schemes. One side of the panels was painted for the chromatic scheme and the other side of the panels was painted for the achromatic scheme. To change the wall color, the panels were slid to the corner and they were inverted to other side which was painted with a different color. The hue yellow-red was decided to be used for chromatic scheme of the experiment as it was the most

preferred hue among other hues in an earlier study which is a field survey. Moreover, monochromatic color scheme was chosen for the chromatic scheme of the experiment (Fig. 1-2). Natural Color System (NCS) was used in specification and selection of the surfaces' and furniture's colors for both color schemes as it was available on the market. It was important to use the colors with the same lightness (reflectance) values on the surfaces of achromatic and chromatic schemes to control the variables and measure only the *hue* effect. Moreover, the selected colors were considered to be in the range of recommended reflectance values for an office environment (for ceilings: 87%, walls: 68%, furniture: 30% and floors: 20% reflectance).

## 2.2. Methodology: Experimental Procedure

The sample group was 60 office workers who are the academic and administrative staff from different departments of the Bilkent University in Ankara, Turkey. They were selected randomly among all the office workers of different departments and they participated in the experiment voluntarily. The mean ages of the participants was 30, 50 and among

these participants 36 of them were female and 24 were male. The experiment did not concentrate on the effects of age and gender on the independent variables. The same sample group participated in the experiment in office settings with different color schemes.



Fig. 1

A view from chromatic scheme

Fig. 2

A view from achromatic scheme

In this study, it was decided to conduct a *within-subject design*; the same sample group participates in two color scheme conditions of the experiment room, to control the effects of the individual differences such as age, sex, intelligence and prior experience in the evaluation of the offices, and task performance. Yet, this design has a disadvantage of providing learning effect. To control the learning effect, a *counterbalancing* technique was designed. A sample group consisted of 60 participants was divided into two equal groups randomly; Half of the participants firstly experienced the office setting applied with achromatic scheme, then, they experienced the office setting with chromatic scheme, the other half of the group experienced the office settings in the opposite order. Moreover, participants were assigned to perform two different but par-

allel performance tests for each setting to control the learning effect of tests. For this study, two different kinds of tasks were used: problem solving and proofreading tests. The Raven's Progressive Matrices was used as a problem solving task that was designed to measure a person's ability to form perceptual relations and to reason by analogy. It was prepared to be used with persons ranging in age from 6 years to adult independent of language, educational background, career experiences, etc.[6]. The other task used in this study was a proofreading task. Four different paragraphs were prepared to be solved for two experiments. Each participant was asked to solve two different paragraphs in each experiment.

The experiment was conducted in the following phases; the participants were taken to the experiment room one by one on the dated hour of day. In the experiment room, participants were firstly tested for color vision with Ishihara color blindness test, and there was no one who was color blind. After a few minutes for adaptation, the experimental procedure was explained to them. Each participant firstly performed the given task consisting of problem-solving and proofreading tests while the coordinator of the experiment was timing this process. Later, the participants evaluated the task they performed (self-report of the task) in 5 point scale likert-type questions. When these phases concluded, participants were asked when it would be possible for them to participate in the second experiment for the office setting with the other color scheme. Thus, second experiment was scheduled as there was going to be a four- day period between the two experiments. In the second experiment, participants performed the given task that was different from the first one yet, made up of parallel tests. They also evaluated the task they performed.

### 3. RESULTS AND DISCUSSION

Statistical Package for the Social Sciences (SPSS) 13.0 was used to analyze the data of the study. Results of the statistical analysis were indicated with respect to the research hypotheses of the study. First of all, since the participants were from the same sample group, whether there was a learning effect of the task performance that may influence reliability of measuring the hypotheses was measured. The learning effect on the group participating in the first experiment with the achromatic scheme and the group participating in the second experiment with the achromatic scheme was analyzed with an independent sample t-test. The same procedure was followed for the chromatic scheme too. The data collected from performance tasks was analyzed, measuring accuracy depending on error numbers, and measuring the speed of performance. The results of the independent t-test indicated that there is not a significant difference between the groups in terms of accuracy (for achromatic scheme;  $t = .730$ ,  $df = 58$ ,  $p = .468$ , for chromatic scheme;  $t = .786$ ,  $df = 58$ ,  $p = .435$ ) and speed of task performance (for achromatic scheme;  $t = 1.330$ ,  $df = 58$ ,  $p = .189$ , for chromatic scheme;  $t = -.872$ ,  $df = 58$ ,  $p = .189$ ). After it was found that there is not a learning effect of task performance, the effects of color scheme on the task performance was analyzed again by measuring accuracy, the success depending on performing an action with the fewest errors, and measuring the speed of performance depending on performing in the shortest possible time. The paired sample t-test was used for the analysis because the same sample group participated in the experiments as mentioned before. The results of the paired sample t-test indicated that there is a significant difference between achromatic and chromatic scheme in terms of accuracy ( $t = 3.889$ ,  $df = 59$ ,  $p = .000$ ) and speed of task performance ( $t = 3.264$ ,  $df = 59$ ,  $p = .002$ ) (Table 2). The mean values of the

number of errors and time showed that participants' performances were better in the chromatic scheme than in the achromatic scheme (Table 3).

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 errornumber in achromatic errornumber in chromatic	1,033	2,058	,266	,502	1,565	3,889	59	,000
Pair 2 time in ach - time in ch	,46550	1,10484	,14263	,18009	,75091	3,264	59	,002

Table 2. Paired sample T-test for differences between achromatic and chromatic schemes in terms of task performance (accuracy and speed)

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Error number in Achromatic scheme	1,90	60	2,113	,273
	Error number in Chromatic scheme	,87	60	,982	,127
Pair 2	Time (in minutes) Achromatic scheme	4,7952	60	1,58557	,20470
	Time (in minutes)Chromatic scheme	4,3297	60	1,33336	,17214

Table 3. Mean values of error number and speed.

Furthermore, the self-report of the performance task that concerns the participants' perceptions about their success and attention was analyzed. The analysis with Wilcoxon Signed Rank test indicated that there is not a significant difference between achromatic and chromatic scheme in terms of self-report of the task performance (for the first question;  $z = -1.519$ ,  $p = .129$ , for the second question;  $z = -.723$ ,  $p = .467$ , for the third question;  $z = -.539$ ,  $p = .129$ , for the forth question  $z = -.972$ ,  $p = .331$ ).

According to the analysis of task performance, it was found that participants' performance was better in chromatic scheme than their performance in achromatic scheme. This result shows similarities with the previous studies in the literature. A study conducted about the workers' performance in white, green or red office interiors indicated that participants made significantly more errors in the white office than the participants in the red and green offices [4]. In another study on the effects of nine different hues on the workers productivity, the findings showed that participants performed worse in the white office interior than in offices with any of the other hues [7]. On the other hand, the results of self-reports of the task performance indicated that there is not a significant difference between achromatic and chromatic schemes. This result shows similarity with a previous study examining the effects of study environments

on adult students' mood satisfaction, motivation and performance. It was found that task perception was not affected by the variables of environment [8].

#### 4. CONCLUSION

The quality of physical environment in workplaces is important for the workers' physical comfort and productivity [1, 2, 9]. In this respect, color was expected to affect workers' visual health, subjective impression, and productivity in the office environment [10]. In this experiment, to analyze the differences between achromatic and chromatic schemes in task performance and self-report of the task, participants were required to perform problem-solving and proof-reading tasks. In the literature, there are not any studies comparing achromatic and chromatic color schemes applied to all of the surfaces in an office environment. Different from other color studies, the *hue* effect on the collective impressions of the offices and participants' performance was investigated in this study. Therefore, the colors on the surfaces of achromatic and chromatic schemes had the same value (lightness).

The data collected from the experiments was analyzed statistically and the results showed that participants' performance was better in the chromatic scheme than their performance in the achromatic scheme. The results of this study can be useful for interior designers in general and for the designers who use color as a design element to enhance environmental quality in the office environment. The ubiquitous uses of white colored walls and dark colored office furniture in workplaces need to be taken into consideration again by designers to create more dynamic and visually comfortable workplaces. In this study, it was initially seen that a moderate increase in the use of good color design can serve to improve the overall comfort and productivity of the workers. In the further studies, whether there are demographic effects such as age, gender, and profession on task performance can also be explored, which was not considered in this study.

#### 5. REFERENCES

1. Galitz, W. O., *The office environment*, Administrative Management Society Foundation, Willow Grove, Pennsylvania, 1984, ISBN 0916875016.
2. Visher, C. J., *Environmental Quality in Offices*, Van Nostrand Reinhol, New York, 1989, ISBN 0442204981.
3. Ainsworth, R. A., Simpson, L. and Cassell, D., "Effects of three color in an office interior on mood and performance", *Perceptual and Motor Skills*, Vol.76, 1993, pp.235-241.
4. Kwallek, N., & Lewis, C. M., "Effects of environmental color on males and females: A red or white or green office", *Applied Ergonomics*, Vol.21, No.4, 1990, pp. 275-278.
5. Küller, R., Mikellides, B. and Janssens, J., "Color, arousal, and performance- A comparison of three experiments", *Color Research and Application*, Vol, 34 No.2, 2009, pp. 141-152.
6. The Raven's Progressive Matrices (2010). Retrieved April 28, 2010 from [http://en.wikipedia.org/wiki/Raven's\\_Progressive\\_Matrices](http://en.wikipedia.org/wiki/Raven's_Progressive_Matrices).
7. Kwallek, N., Lewis, M. C., Lin-Hsiao, J. M. D. and Woodson, H., "Effects of nine monochromatic office interior colors on clerical tasks and worker mood", *Color Research and Application*, Vol.21, No.6, 1996, pp. 448-458.
8. Stone, N. J., "Designing effective study environments", *Journal of Environmental Psychology*, Vol. 21, 2001, pp. 179-190.
9. Sundstrom, E. (1986). *Work Places: The psychology of the physical environment in offices and factories*, Cambridge University Press, Cambridge, 1986, ISBN 0521319471.
10. Marberry, S. O. and Zagon, L., *The power of color: Creating healthy interior spaces*, John Wiley & Sons, Inc, New York, 1995, ISBN 0471076856.