

MODELING ENVIRONMENTAL ERGONOMICS,

BY SUBLIMINAL EFFECTS OF VISUAL FACTORS ON REDUCING ENVIRONMENTAL STRESS

(Case Study: Public Sector)

ABSTRACT

The present study aims to propose ergonomic models by introducing the most contributing lighting and color spectrums for stress reduction in the physical work environment. This aim will be achieved by studying the subliminal effects of two environmental visual factors, color and lighting, as independent variables on the reduction of environmental stress, a dependent variable. In this investigation, the subliminal message acts as an intervening variable. Given that the case study in this research focuses on the public sector; the staff of a sample public organization will be selected as the statistical population. Using Krejcie and Morgan's table, n samples will be chosen through proportionate stratified random sampling. As an applied study, the methods adopted by the current research are quasi-experimental and explanatory. The data collection instruments include observation, interviews, and questionnaires with acceptable validity and reliability. Finally, the practical environmental ergonomic patterns for the workplace, particularly, organizational environments, will be proposed based on the two visual factors of color and lighting. Since reducing workplace stress is one of the main objectives of the organizational behavior field, the results of the current study can benefit top-level management, especially, that of organizational behavior and human resources.

Keywords: Human factors engineering, Subconscious perception, Color psychology, Light ergonomics, Work-related stress

INTRODUCTION

One of the global consequences of the Industrial Revolution was the thought that employees are merely a means of producing goods and services. However, over time, this perception has changed due to a significant amount of research that has focused on human factors. In today's competitive business world, the employee is a critical asset to every organization. According to Kaplan and Norton (2004), human resources account for more than 75% of an organization's value and constitute its most essential capital. This is particularly true for public organizations which are responsible for the welfare of citizens and the realization of economic, social, and cultural aspirations. Thus, the satisfaction of employees with working conditions, including social and physical environments, plays a significant role in organizational success (Saadat, 2014). This is why management must identify factors contributing to the well-being of employees and decrease work-related stress accordingly. In this regard, one of the main determining factors in work-related stress reduction is improving the condition of the physical work environment, a task which falls in the field of environmental ergonomics. In the world of management, ergonomics is also known as human factors engineering. Given the role of ergonomics in creating an interaction between the environment and the physical and psychological needs of humans (Wilson, 1995), the present study aims to model environmental ergonomics by determining the effects of visual factors on stress reduction. As a result, this study shall attempt to achieve the main goal of ergonomics and fit the work environment to the individual, not the reverse. It is worth noting that, by applying ergonomics principles and making the physical work environment more accommodating for employee's needs, organizations will show their appreciation for employees as assets.

PROBLEM STATEMENT

As the world continues to be modernized and industrialized, humans experience even more psychological and mental stress. This is a pressing issue that resides in the workplace. To deal with the growing problem of work-related stress, managers must identify the specific sources of stress and take clear measures to address them (Allie, 1996). One of the major areas to address is the physical work environment (Gutnick, 2007). Proper (1998) emphasizes that an effective work environment should provide positive sensory stimulation through the proper use of color, lighting, aroma, space, and furnishings. These elements are critical for efficient work and lead to increased productivity. However, today, most workplaces, particularly, in the public sector, are established without any consideration for their negative effects on the employee's mental well-being. This is a serious issue mostly found in third world workplaces which is accountable for creating environmental stress. It is worth noting that the application of ergonomic principles to maintain environmental workplaces standards is a major contributing factor to work-related stress reduction. Therefore, the failure to implement ergonomic principles at the workplace can lead to emotional depression, physical exhaustion, and declining productivity (Shikdar et al., 2003).

To underscore the significance of this study, it is worth mentioning that nowadays, there is a greater application of ergonomic principles in the private sector. This is because the preoccupation of top managers, especially in public sector, is mainly to pursue an organization's mission statement. Consequently, there is little time to devote to issues such as maintaining the physical work environment and, in particular, environmental factors that affect employee's mental health. Findings of the present study can benefit top managers, particularly organizational behavior and human resource managers. Given that the case study in this research will focus on the public sector, the relationship between human resource managers, organizational psychologists, and ergonomists will be promoted.

The objectives of the present study are to:

- **G. 1:** Determining the potential problems of the work environment's visual factors
- **G. 2:** Determining the subliminal effects of colors on reducing environmental stress
- **G. 3:** Determining the subliminal effects of lighting on reducing environmental stress

LITERATURE REVIEW

In 1990, the World Health Organization (WHO) declared that more than 30% of all work environments suffer from a disorder named Sick Building Syndrome (SBS)¹. SBS is the result of substandard and poor physical conditions of the workplace. This condition exerts undesirable physical and mental effects on people working in these areas. Different studies introduce various factors as the major causes of SBS, such as overcrowded and noisy work environments, poor interior design, inappropriate temperatures, and other factors related to the physical work environment (Norback et al., 1990). With regard to the dire effects of SBS on the mental health of employees, environmental ergonomics proposes some applicable principles and models for maintaining a suitable work environment. Clearly, the concept of a suitable environment is well-integrated into the 'cybernetic model,' as advanced by Cooper and Dewe (2004). This model focuses on a person-environment interaction as a system, in which individuals constantly modify the environment while adjusting and adapting behavior to fit that environment (Vischer, 2007). Similarly, according to the ergonomic approach, there is a relationship between the physical work environment and human behavior, as a cybernetic model (Rezapour, 2013).

¹ WHO. Indoor Air Quality: Biological Contaminants. 1990; WHO regional publications, European series No. 3, pp.1-54. Available at: www.WHO.int, 12.5.2008

Environmental ergonomics is an integral part of the ergonomics discipline which deals with human behavior in the face of various environmental factors, such as lighting, temperature, noise, vibration, etc. (Parsons, 2000). Focusing on physical factors and their effect on environmental stress reduction, the present study falls under the area of environmental ergonomics. For this purpose, out of the three environmental factors, such as visual, auditory, and sensory, the current study will investigate visual features. Therefore, the two closely interacting visual factors of color and lighting will be studied.

What distinguishes the present study from other ergonomics research is its investigation of qualitative ergonomic variables in the work environment, which has attracted little attention from researchers. In fact, previous studies have mainly dealt with the quantitative measurement of environmental factors and the determination of established standards for factors, such as temperature (°C/°F), noise (dB), vibration (Hz), and lighting (Lux). For example, in 2000, Parsons reviewed the principles, methods, and models used in environmental ergonomics in terms of the effects of heat and cold, vibration, noise and light on the health, comfort, and performance of employees. The study mostly focused on the quantitative measurement of environmental factors. What differentiates the present study from Parsons' research is its consideration of the qualitative environmental factor of color. The qualitative analysis of lighting in environmental ergonomic field also distinguishes this study.

In order to explain the present study's conceptual framework (Fig.1), three study variables, i.e. environmental factors, visual subliminal messages, and environmental stress, will be briefly discussed here:

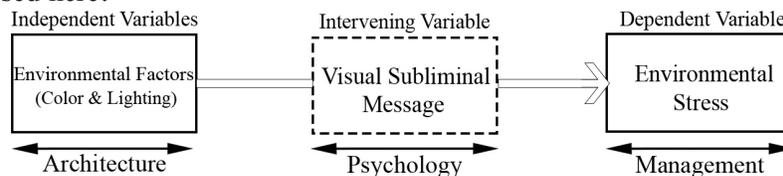


Fig. 1. Conceptual framework

1. Independent variables: Color and Lighting

Johannes Itten (1888-1967) maintains, "Color is life; for a world without colors appears to us as dead." Introducing appropriate color design into the work environment will boost the mood and well-being of people (Küller et al., 2009). According to research by Ward (1995), colors can influence emotions and serve as tools to help employees manage stress. Therefore, color can be soothing, invigorating, jarring, or stress-inducing (Pelegrin-Genel, 1996).

It is worth noting that there has been a greater application of ergonomic principles in the private sector. As a result, most studies on color and color therapy deal with the application of color in private residential or business environments while little work has addressed the effect of color on employees in the public sector. This is exactly one of the gaps which the current study aims to fill. In analyzing the effects of various colors on employees, the present research utilizes the concept of color psychology and its impact on environmental stress reduction. Furthermore, it takes into account the underlying meaning and history of colors with respect to the customs and culture of the country used as a case study. A few studies have shown that cultural background has a strong influence on color preference. In fact, people from the same region, regardless of race, will have the same color preferences (Whitfield et al., 1990).

It should be noted that there is no color without light. According to Frank (2000), lighting is a critical element in creating a comfortable work environment. Hower (1995) emphasized that light influences the endocrine system, cardiac rhythm, Seasonal Affective Disorder (SAD) and the body clock, while also regulating fatigue and stress. Considering the mutual

and close relationship between light and color, it is necessary for the present research to focus on the interrelationship between these two visual environmental factors.

It is important to pay attention to the quantity as well as the quality of lighting in the workplace (Hower, 1995). Therefore, since the quantitative measurement of light intensity has already been established, the present study will investigate the subliminal effects of “cool and warm lights” on mental well-being. The scale of “Color Temperature,” measured by Kelvin, describes the color appearance of light, including warm or cool light. A higher color temperature is considered to be visually cooler, while lower temperatures are perceived as being warmer. It is worth mentioning that, since fluorescent lighting is a source of interest and concern (Veitch et al., 1993), compact fluorescent lamps (CFL) will be used as the main light source in the present investigation. Lighting and color will be regulated in various places where employees spend most of their time, such as in private offices, meeting rooms, and common areas.

2. *Intervening variable: Subliminal Effect*

According to one of the main assumptions of environmental psychology, many environmental influences are subliminal². Color and lighting are among the subliminal factors affecting employees who spend most of their time working with computers in a sitting position. The subliminal power of color derives from the fact that most people do not consciously think about color, but instead unknowingly react to it with feelings. In fact, one's appreciation of color is more emotional or affective, rather than intellectual or cognitive³.

Subliminal messages are stimuli that lie below the absolute threshold level of conscious awareness. Therefore, these messages cannot be directly perceived. Generally, there are two types of subliminal messages: visual stimuli and auditory stimuli (Loftus et al., 1992). In order to study the effects of subliminal stimuli, researchers will often prime subjects with specific stimuli and determine if those stimuli elicit different responses (Williams et al., 2006). The main aim of the present study in modeling environmental ergonomics will be achieved by investigating the visual stimuli of two environmental factors, color and lighting, on environmental stress reduction.

In the present study, the intervening variable of a subliminal message acts as a latent variable. As noted earlier, a subliminal message cannot be directly perceived. A latent variable, as opposed to observable variables, is a variable that is not directly observed but rather inferred by a mathematical model. (Habibi, 2013). This variable is not measured directly but assumed to underlie observable measures. In fact, it is "really there," but hidden.

3. *Dependent variable: Environmental Stress*

Stress at work is an increasingly common feature of modern life (Cooper, 1998). It is feedback of an individual on his/her environment (Piko, 2006) and one of the factors which has been studied to investigate human behavior at work. Excessive work-related stress or occupational stress can damage the physical and emotional well-being of an employee (Allie, 1996). Research by the Industrial Society in London found that 74% of the employers surveyed predicted that work-related stress would become their greatest health and safety concern in the next few years (Alder, 2001). The present study will investigate the area of work-related stress which is known as environmental stress. The study of environmental stress focuses on the relationship between individuals and the work environment stressors. Stressors include physical environmental factors, which exert negative responses on

² Introduction to Environmental Psychology. (n.d.). In Martintolley. Retrieved June 17, 2015, From <http://martintolley.com/environment/IntroEnvPsy1.html>

³ Subliminal Advertising through Color. (n.d.). In Coloracademy. Retrieved May 22, 2015, From <http://www.coloracademy.co.uk/ColorAcademy%202006/subjects/advertising/page2.htm>

employees. These negative responses can be caused by poor work conditions, such as overcrowded and noisy work environments, poor interior design (light and color), inappropriate temperature, humidity, and other factors related to the physical work environment (McLean, 2008). Most researchers, such as Kets de Vries (1979), Smith (1994), and Dua (1994), agree that work stress is caused by work design and workplace environment (Makhbul et al., 2007). Therefore, considering the present research's aim to model environmental ergonomics, the effects of visual factors on environmental stress reduction will be studied.

The following research questions will be addressed:

4. Research Questions

- **Q. 1:** To what extent do the visual factors of color and light reduce the level of environmental stress?
- **Q. 2:** Which color and light spectrum can be modeled as the most significant contributing factor of environmental stress reduction?

RESEARCH METHODOLOGY

As an applied study, the methods adopted by the current research are quasi-experimental (pretest-posttest control group design) and explanatory. Given that the case study in this research focuses on the public sector, the staff of a sample public organization will be selected as the statistical population. Using Krejcie and Morgan's table, n samples will be chosen through proportionate stratified random sampling. The data collection instruments include observation, interviews, a self-report study, and questionnaires with acceptable validity and reliability. The questionnaires will focus on the study's linguistic data concerning the impact of the two visual factors on environmental stress reduction. The survey answer format includes Likert scales (e.g., strongly disagree to strongly agree). The interviews will capture opinions and experiences of employees in their physical work environments. The present research will benefit from the views of three groups, namely employees, managers, and experts in the areas of architecture, ergonomics, and interior design. It is worth mentioning that, in data collection, the present study also benefits from archival studies, public documents, and accessible databases related to the subject of the research. Finally, by modeling the present research's findings, practical environmental ergonomic patterns for the workplace will be proposed based on the two visual factors of color and lighting.

The current study will span three phases of literature, field, and modeling studies:

1. Phase One (Literature Studies)

The purpose of this stage is to collect the basic and necessary data for conducting a field study. Therefore, literature and theories related to the main concepts of the research, namely environmental ergonomics, subliminal stimuli, and environmental stress, will be studied. Furthermore, in order to complete the theoretical framework of the research, a number of successful case studies will be investigated in which environmental ergonomics has been applied in the public sector.

2. Phase Two (Field Studies)

The purpose of this stage is to apply the theoretical contents of Phase 1 of the study to the workplace and realize the objectives of the research.

Note: To illustrate the second Phase of the research, consider the following example. It is based on the statistical information of the researcher's own workplace, which can be changed according the conditions of the new case study.

Suppose that the total number of employees of a sample public sector is 141 people who work in two departments: **A** (71) and **B** (70). Departments **A** and **B** can have different functions, such as technical departments and administrative departments. Using Krejcie and Morgan's table, 100 samples will be chosen through proportionate stratified random sampling. Therefore, 50 samples will be selected from Department **A** and 50 from Department **B**. Then, n:20 rooms in both departments will be considered as samples to perform testing; this includes 10 rooms for each department with the capacity of 5 subjects. The 10 rooms allocated to Department **A** consist of 8 treatment and 2 control groups. The same division will be made for Department **B**. The control groups do not receive experimental treatments or other manipulations of the independent variables. The purpose of having a control group is to monitor the impact of the events and other stress-related problems that may affect the mental health of the test samples. In this case, the researcher will be considered the simultaneous effect of unwanted variables on the results of the treatment groups. Since the two departments, **A** and **B**, have different functions, the results will be compared based on the different characteristics of the samples. It should be noted that the combination of 8 treatment groups in the two departments consist of 4 male and 4 female groups. The purpose of this categorization is to determine the subliminal effects of visual factors on reducing environmental stress by taking into account the gender factor. Considering the methodology of the current research in using the quasi-experimental and pretest-posttest control group design, the field studies consist of three stages:

- **Part 1:**
In order to determine the potential problems of the work environment's visual factors and their impact on environmental stress reduction, first, an initial test will be carried out on all subjects. The results are the findings of pretest (**S1**) which will be conducted via observations, interviews, and questionnaires. This is called the problem diagnosis step which realizes the first objective of the research.
- **Part 2:**
This step consists of maintaining the test conditions using an optimum light/color spectrum, resulting from Phase 1 and monitoring the changes. (1 year).
- **Part 3:**
In this stage, the second test or posttest will be carried out to determine the reduction in environmental stress (**S2**). By comparing the pretest/posttest's findings (ΔS), in fact, this step estimates the significance of the visual factors' positive changes to environmental stress. It is worth mentioning that, along with other data collection instruments, medical tests will be carried out as an additional measurement to ensure the accuracy of the results. Finally, the best color and light spectrum will be proposed as the most significant contributing factor in environmental stress reduction, a point which pursues the research goals and answers research questions.

3. Phase Three (Modeling Studies)

The purpose of the third Phase is to pursue the main objective of the research in proposing environmental ergonomic models, based on the factors of color and lighting

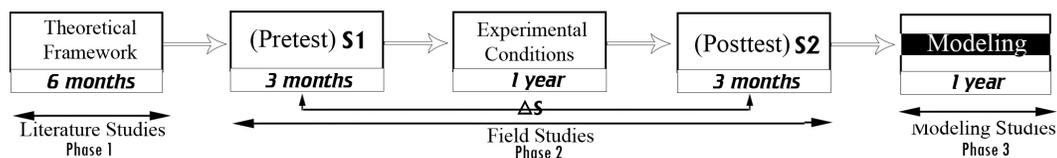


Fig. 2. Research Plan

REFERENCES

- Alder, C. (2001). *Work stress*. Business Insurance, 35. Retrieved September 20, 2002, from Busindustry Database.
- Allie, P. (1996). *Psychological stress in today's office environment*. Supervision, 57, 3. Retrieved September 20, 2002, from Wilson Select Plus Database.
- Cooper, C., & Dewe, P. (2004). *Stress, a brief history*. Oxford: Blackwell Publishing, p.97.
- Cooper, C. (1998). *The Future of work – A strategy for managing the pressures*. Journal of Applied Management Studies, 7(2): 275-281.
- Dua, J.K., (1994). *Job stressors and their effects on physical health, emotional health, and job satisfaction in a university*. Journal of Educational Administration, 32(1): 59-78.
- Frank, L. S. (2000). *The light of the world*. Buildings, 94, 66. Retrieved May 19, 2007, from Wilson Select Plus Database.
- Gutnick, L. (2007). *A workplace design that reduces employee stress and increases employee productivity using environmentally responsible materials*. Master's Theses and Doctoral Dissertations, Paper 151, p.2.
- Habibi, A. (2013). *Multiple-criteria decision analysis*. Tehran: Tehran University Publishing. p.319
- Hower, K. B. (1995). *The mind and body connection*. Interior & Resources, 64-67. September 15, 2001 from Wilson Select Plus Database.
- Kaplan, R., & Norton, D. (2004). *Strategy maps: converting intangible assets into tangible outcomes*, Harvard Business School Press.
- Kets de Vries, M.F.R., (1979). *Organizational stress: A call for management action*. Sloan Management Review, 21(1): 3-14.
- Küller, R., Mikellides, B. & Janssens, J. (2009). *Color, arousal, and performance—A comparison of three experiments*, Color Research & Application, 34(2), 141-152.
- Loftus, E. F. & Klinger, M. R. (1992). *Is the unconscious smart or dumb?*. American Psychologist 47 (6): 761–765. doi:10.1037/0003-066X.47.6.761. PMID 1616173.
- Makhbul, Z.M., Idrus, D. & Rani, M.R. (2007). *Ergonomics design on the work stress outcomes*. Jurnal Kemanusiaan, 33: 201-213.
- Manoharan, P.K, Sanjay, J. & Singh, B.K. (2011). *Modeling the risk factors in ergonomic processes*. International conference on computer, informatics, cybernetics and applications.
- McLean, J. (2008). *Stress and job satisfaction among distance educators*. Pennsylvania College of Technology.

- Norback, D., Torgen, M., & Edling, C. (1990). *Volatile organic compounds, respirable dust, and personal factors related to prevalence of Sick Building Syndrome in primary schools*. *Br J Ind. Med*, 47(11):733-41.
- Parsons, K.C. (2000). *Environmental ergonomics: a review of principles, methods and models*. *Journal of Applied Ergonomics*, 31, 581-594.
- Pelegrin-Genel, E. (1996). *The office*. New York: Flammarion.
- Piko, B.F. (2006). *Burnout, role conflict, job satisfaction and psychosocial health among Hungarian health care staff: a questionnaire survey*. *International Journal of Nursing Studies*, 43: 311-318.
- Proper, E. (1998). *Surroundings affect worker productivity; office design is more than cosmetics*. *Industry week*, 247(11), 14. Retrieved October 17, 2001, from Wilson Select Plus Database
- Rezapour, A. (2013). *The role of ergonomics in occupational stress*. *Journal of Safety, Health and Environmental Studies*, 10(5), 10-17.
- Saadat, E. (2014). *Analysis of job satisfaction of human resources in the public sector*. *Humanities Quarterly*, 8(13), 18.
- Shikdar, A.A. & Sawaqed, N.M. (2003). *Worker productivity and occupational health and safety issues in selected industries*. *Computers and Industrial Engineering*, 45(4): 563-572.
- Smith, S.L. (1994). *Combating stress*. *Occupational Hazards*. 56(3): 57-59.
- Veitch, J. A., Hine, D. W., & Gifford, R. (1993). *End users' knowledge, preferences, and beliefs for lighting*. *Journal of Interior Design*, 19(2), 15-26.
- Vischer, J. C. (2007). *The effects of the physical environment on job performance: towards a theoretical model of workspace stress*. *Stress and Health*, 23: 175–184. doi: 10.1002/smi.1134
- Ward, G. (1995). *Colors and stress reduction*. *Supervision*, 56, 3-5. Retrieved September 20, 2002, from Wilson Select Plus Database.
- Whitfield, T. W. & Wiltshire, T. J. (1990). *Color psychology: a critical review*. *Genetic, Social and General Psychology Monographs*, 116 (4), 387.
- Williams, L. M., Liddell, B. J., Kemp, A. H., Bryant, R. A., Meares, R. A., Peduto, A. S. & Gordon, E. (2006). *Amygdala–prefrontal dissociation of subliminal and supraliminal fear*. *Human Brain Mapping*, 27 (8): 652–661. doi:10.1002/hbm.20208. PMID 16281289.
- Wilson, J.R. (1995). *Solution ownership in participative work redesign*. *International Journal of Industrial Ergonomics*, 15: 329-344.