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*The Effect of
Fluorescent Light Flicker and
Lamp Type on the Health,
Productivity and Satisfaction of
Data Entry Personnel:
An Interventional Study*

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Abstract

Fluorescent lighting has been highlighted as a significant factor in eyestrain, headache, lethargy and other asthenopic (eye related) complaints by office personnel. These three symptoms rate amongst the most highly reported complaints attributed to the office environment.

An interventional study was conducted in three data entry offices to assess the effect of fluorescent light flicker and modulation depth on the incidence and severity of common workplace symptoms, productivity and satisfaction with the work environment.

Each of the three offices had three lighting regimes installed for a four week period in a crossover design with an initial four week baseline period. The three lighting treatments were selected to represent commonly available lighting conditions and included triphosphor fluorescent tubes with high frequency electronic ballasts and low frequency magnetic ballasts and halophosphate fluorescent tubes with low frequency magnetic ballasts.

The study provided evidence to suggest that eyestrain and lethargy symptoms were considered to be more severe in the low frequency halophosphate lighting treatment. There was also a higher incidence of lethargy symptoms in the low frequency halophosphate lighting treatment. In addition, significant relationships were present between perceived decreased productivity (due to the work environment) and increased symptom severity in the low frequency halophosphate lighting treatment. The low frequency and high frequency triphosphor lighting treatments did not differ significantly. No significant relationships were shown between actual or perceived productivity and lighting treatments.

There was no evidence to suggest that participants were able to perceive flicker from any of the lighting treatment installations on a consistent basis. When participants perceived flicker it was not considered to be disturbing or annoying.

The actual productivity of participants was related to eyestrain and lethargy symptoms in one of the offices studied. The effect size was small to medium, explaining between 2-5% of the variability of the data. Actual productivity was not related to any other measures. Office personnel perceived that their productivity (due to the work environment) and work satisfaction was strongly affected by the eyestrain, headache and lethargy symptoms experienced.

These results did not show that flicker frequency or modulation depth affected the severity of eyestrain, lethargy and headache symptoms, the satisfaction of the occupants or their perceived or actual productivity. These findings support previous research that has suggested that differences in task performance may be limited to difficult visual tasks with minimal cognitive or motor components. Further, these results suggest that the effect of low frequency flicker on asthenopic symptoms may also be small and easily overwhelmed by other workplace factors. The breadth of this study was ambitious and featured limitations (such as small sample sizes) that may have impacted on the results found in some analyses. This study may not have been sensitive enough to detect small differences in the health, productivity and satisfaction of office personnel due to fluorescent light flicker.

The pattern of responses examined alongside research in this field suggested that differences in the spectral distribution of the tubes may be a culpable factor. A small colour component in the work task and an equally small luminance difference between lighting treatments may have contributed to this finding. However, given that there is limited support for this outcome in the literature, and the previous findings in research examining fluorescent light flicker, these results should be considered as exploratory.

Taken together, the research findings present a compelling argument for additional field research. This study provides a foundation that will enable future studies to further quantify the relationships between health, productivity and qualitative aspects of lighting in the work environment.

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Introduction

The internal office environment can have a significant effect upon the health, productivity and satisfaction of office personnel. Numerous research studies have shown that aspects of the indoor environment including indoor air quality, lighting, acoustics and thermal conditions can influence how people feel and behave in the work environment.

Lighting is one factor that many office personnel feel is a significant contributor to health symptoms in the workplace. Since the development of fluorescent lighting, people working under its illumination have complained about eyestrain, headache, eye fatigue, and other asthenopic complaints that they attribute to the light source. The flicker from fluorescent tubes has been identified as one of the culpable factors by subjective comments from subjects working under such lighting.

This interventional field study examined lighting related health symptoms, productivity and satisfaction of office personnel exposed to three lighting treatments with differing flicker frequency and luminous variation (modulation depth) in their work environment.

The study extended previous reported research studies by measuring objective task performance, physical sensations (eyestrain, headache and lethargy) and perception of the workplace under actual office environment conditions. The relationship between these variables is not well understood in the field of building health and there are limited studies in the lighting arena that have attempted to understand the relationship between these factors. In addition to monitoring the lighting conditions within the subject buildings, other environmental factors that may have contributed to the symptoms, productivity or satisfaction of the office personnel were monitored, and these were examined to determine their contribution to participants' responses.

A medical examination of approximately one third of the staff in each of the three offices was undertaken at the conclusion of the study to isolate factors that may have predisposed the office personnel to lighting related symptoms. The extent to which non-

work related factors contributed to symptoms experienced during the work shift was also explored.

The lighting technologies utilised in the study also have implications for energy usage in buildings. Lighting is a major consumer of energy in commercial buildings, contributing to up to 30% of the energy consumption of the building. The electronic ballasts and triphosphor fluorescent tubes utilised in this study are energy efficient in comparison to conventional magnetic ballasts and halophosphate fluorescent tubes, presenting up to a 25% saving in energy consumption. Thus the study also had the potential to support the promotion of energy efficient and environmentally friendly lighting solutions for modern office buildings.

The thesis is set out as follows: the specific aims and hypotheses are stated, followed by a review of the literature (Chapter One). The experimental methodology is then outlined in Chapter Two, followed by the results and discussion pertaining to these specific sections in Chapter Three. Two further chapters outline the environmental monitoring that was undertaken in the host offices and a medical study that was undertaken at the conclusion of the main study. The general discussion and final conclusions describe the primary findings of the study in relation to the research aims and hypotheses and previous research in this field. Study limitations and alternative explanations for the findings are outlined. The contribution that this study makes to the literature and directions for future research is discussed. A glossary is then included followed by the appendices. Finally, the references used in the thesis and a selected bibliography concludes this body of work.

Specific Aims

1. To determine whether it is possible to reduce the incidence and severity of eyestrain, headaches and lethargy experienced by office personnel by altering the flicker frequency and modulation depth of commercially available fluorescent lighting.
2. To determine whether differing flicker frequency or modulation depth influence the actual productivity of office personnel, the perceived effect of the work environment on their productivity, or their satisfaction with the work environment.
3. To examine the relationship between symptoms experienced in the workplace, actual productivity, the perceived effect of the work environment on productivity and satisfaction with the work environment.
4. To examine the role of personal characteristics, external and environmental factors in relation to symptoms experienced by office personnel.
5. To determine whether or not energy efficient lighting technologies affect the health of office personnel.

Research Hypotheses

1. That increased flicker frequency and reduced modulation depth of fluorescent lighting will decrease the incidence and severity of eyestrain, headache and lethargy symptoms reported by office personnel; will increase perceived and actual productivity; and will increase satisfaction with the work environment.
2. That symptom incidence and severity is related to perceived and actual productivity and satisfaction with the work environment.
3. That physiological characteristics such as visual aberrations, migraine and high blood pressure influence the incidence and severity of lighting related symptoms.