



**THE EFFECTS OF NATURE SOUND IN OPEN-PLAN  
OFFICE ON PERCEIVED PSYCHOLOGICAL  
RESTORATION AND COGNITIVE PERFORMANCE**

**BY**

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## ABSTRACT

Studies in the area of psychological restoration at the workplace tend to focus on the positive effects of visual natural environments, and limited work has been carried out to explore the potential role that natural auditory stimuli could play in facilitating this process within open-plan office settings. Addressing this gap, the present study investigates the effects of nature sounds and office noises on perceived psychological restoration and cognitive performance of workers in an open-plan office. The study, which took place in the Registry Office at the University Putra Malaysia, involved a total of 50 administrative workers (Males = 15; Females = 35). Using a within-subject repeated measure design, all participants were exposed to four auditive stimuli (geophony, machine-generated noise, biophony, and human-generated noise) for the duration of one month following a specially designed schedule. At the end of each week, participants completed a questionnaire that consisted of background information, the Perceived Restorativeness Scale, and an error detection task. Results of two separate one-way repeated measure ANOVAs revealed that: (1) there is a significant positive effect of nature sounds, specifically the biophony, on perceived psychological restoration; (2) a significant negative effect of office noises, specifically human-generated noise, on perceived psychological restoration; (3) a significant positive effect of nature sounds on cognitive performance; and (4) a significant negative effect of office noises on cognitive performance. Taking these findings together, it can be concluded that exposure to nature sounds, particularly biophony, can bring positive effects to people cognitively and psychologically. In contrast, exposure to office noise, particularly human-generated ones, has significant negative effects on cognitive performance and perceived psychological restoration. Further discussions on the results are presented, together with the implications of the present study and the recommendations for future research.

## ملخص البحث

تميل الدراسات في مجال الراحة النفسية في مكان العمل إلى التركيز على التأثيرات الإيجابية للبيئات الطبيعية البصرية، وقد تم القيام بعمل محدد لاستكشاف الدور المحتمل الذي يمكن أن تؤديه المحفزات السمعية الطبيعية في تسهيل هذه العملية ضمن إعداد المكاتب المفتوحة، وفي معالجة هذه الفجوة، تبحث هذه الدراسة في تأثيرات أصوات الطبيعة والضوضاء المكتبية على الراحة النفسية المتصورة والأداء المعرفي للعاملين في مكتب مفتوح. وتضمنت الدراسة التي أجريت في مكتب التسجيل في جامعة بوترا ماليزيا ما مجموعه (٥٠) موظفاً إدارياً (١٥ = ذكور؛ ٣٥ = أنثى). وباستخدام تصميم قياس متكرر داخل الموضوع، تعرض جميع المشاركين إلى أربعة محفزات سمعية (جيو فوني، وضوضاء ناتجة عن الجهاز، وبيوفوني، وضوضاء من صنع الإنسان) لمدة شهر واحد بعد جدول زمني مصمم خصيصاً لذلك، وفي نهاية كل أسبوع، أكمل المشاركون استبياناً يتألف من معلومات أساسية، ومقياس الراحة المتصورة، ومهمة كشف الأخطاء. كشفت نتائج اثنين من أنوفاس للقياس المتكرر في اتجاه واحد: أن هناك تأثيراً إيجابياً كبيراً من أصوات الطبيعة، وخاصةً بيوفوني، على الراحة النفسية المتصورة؛ والتأثير السلبي الكبير على الضوضاء المكتبي، وخاصةً الضجيج الناجم عن البشر في الراحة النفسية المتصورة؛ والتأثير الإيجابي الكبير من أصوات الطبيعة على الأداء المعرفي؛ والتأثير السلبي الكبير من ضوضاء المكتب على الأداء المعرفي. وباستخدام هذه النتائج معاً، يمكن الاستنتاج بأن التعرض لأصوات الطبيعة، لا سيما الصخور البيولوجية، يمكن أن يحقق تأثيرات إيجابية للناس إدراكياً ونفسياً؛ وعلى النقيض من ذلك، فإن التعرض لضجيج المكاتب، ولا سيما تلك التي ينتجها الإنسان، له آثار سلبية كبيرة في الأداء المعرفي والراحة النفسية المتصورة، وتعرض مناقشات أخرى بشأن النتائج، إلى جانب الآثار المترتبة على هذه الدراسة والتوصيات المتعلقة بالبحوث المقبلة.

## APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion; it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Human Sciences in Psychology (Industrial and Organizational).

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Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Human Sciences in Psychology (Industrial and Organizational).

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Rahamah bt. Ahmad H. Osman  
Dean, Kulliyyah of Islamic  
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## DECLARATION

I hereby declare that this dissertation is the result of my own investigation, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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*This dissertation is dedicated to my beloved parents*

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In the name of Allah, The All- Beneficent, The All-Merciful. All praise is due to Allah (SWT) the Lord of mankind and the universe. All Prayers and Blessings of Allah (SWT) be upon his messenger, our greatest educator, our master, and the best of human being; the Prophet Muhammad (SAW).

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# CHAPTER ONE

## INTRODUCTION

### 1.0 BACKGROUND OF THE STUDY

Previous studies (e.g., Evans & Johnson, 2000; Kristiansen, Mathiesen, Nielsen, Hansen, Shibuya, Petersen, Lund, Skotte, Jorgensen, & Sjøgaard, 2009; Waye, Bengtsson, Rylander, Hucklebridge, Evans, & Clow, 2002) demonstrated the multiple effects of noise and acoustical distraction in open-plan office on employees, ranging from increased levels of stress and discomfort to reduced job satisfaction and performance. More recent studies that compared noise levels in open-plan and cellular offices have also yielded a similar pattern. It showed that employees in the former office type experienced higher sickness absence and poorer well-being than those in the latter (Jahncke, Hygge, Halin, Green, & Dimberg, 2011; Pejtersen, Fèveile, Christensen, & Burr, 2011).

The four common types of open-plan office noise are (1) human-generated noise, e.g., face to face conversation or phone conversation, (2) machine-generated noise, e.g., sound from office machines or phone ringing, (3) impact noise, e.g., sound from opening/closing doors, walking on hard surfaces, and (4) background noise, e.g., sound produced from equipment and surrounding context (Pan & Chan, 2007). The most distractive is human-generated noise, mainly because it is audible, and it can be understood (Jensen, Arens, & Zagreus, 2005; Pejtersen, Allermann, Kristensen, & Poulsen, 2006). Another reason that has been put forward to explain this distractedness is that this type of noise impedes general cognitive performance by disturbing concentration and attention (Liebl, Haller, Jödicke, Baumgartner,

Schlittmeier, & Hellbrück, 2012; Jahncke et al., 2011; Kim & Dear, 2013). The evidence for this cognitive vulnerability was shown in a number of studies found that acoustic exposure affects the speed of text typing and false detections of mistakes in a proof-reading task, which imply that tasks requiring processing of words may be affected by office noise (Balazova, Clausen, Rindel, Poulsen, & Wyon, 2008; Toftum, Lund, Kristiansen, & Clausen, 2012). Similarly, Jahncke et al. (2011) reported that participants in an experiment that simulated office work were unable to give answers to questions when they were exposed to high noise levels; indicating diverted attention between the task given and the noise surrounding them.

In addition to poor sustained attention and concentration problems, constant exposure to office noise also affects physiological function (e.g., increased heart rate and blood pressure), and it contributes to psychological stress (e.g., annoyance and frustration) (Evans & Johnson, 2000; Kristiansen et al., 2009; Morrison, Haas, Shaffner, Garrett, & Fackler, 2003; Waye et al., 2002). These effects can counteract with employees' abilities to appreciate restorative values of the setting in such a way that they are less able to recharge their capacity for attention or recovery from stress. This ability to recharge and to recover is known as *psychological restoration* (Ulrich, 1984), and it is this ability that acts as a buffer against adverse occupational, health, and psychological effects in noise-exposed employees.

However, the majority of the studies on psychological restoration in open-plan office, such as those by Laumann, Garling, and Stormark (2003) and Ulrich, Simons, Losito, Fiorito, Miles, and Zelson, (1991), have mainly investigated visual features that promote psychological restoration (e.g., videos and photographs of natural environments), and not on the sound or auditory stimuli, which could also be potentially useful as intervention. In fact, more recent studies by Mackrill (2013),

Jahncke et al. (2011), and Jahncke, Eriksson, and Naula (2015) supported this idea and suggested that sounds may also influence such process. In particular, natural soundscapes, which include biophony (e.g., sounds created by organisms such as insects, amphibians, birds, and mammals) and geophony (e.g., sounds from the movement of wind and water) (Pijanowski, Villanueva-Rivera, Dumyahn, Farina, Krause, Napoletano, Gage, & Pieretti, 2011), are found to be perceived as pleasant (Lavandier & Defréville, 2006) and may facilitate the recovery effort from stress (Alvarsson, Wiens, & Nilsson, 2010). Together, these studies suggest that nature sounds may have restorative effects; hence, the feasibility of using these sounds in open-plan office to reduce the distractive effects of noise is immensely promising.

Although there are some studies that have investigated nature sounds at workplace (e.g., Jahncke et al., 2011; Liebl et al., 2012), there is still a lack of research exploring the connection between these sounds and their potential restorative qualities in improving employees' cognitive performance and psychological restoration from mental fatigue and stress. Therefore, further studies to better understand the nature and the effects of varying nature sounds on psychological restoration and cognitive performance at work in an open-plan office are necessary.

## **1.1 STATEMENT OF THE PROBLEM**

An office, regardless of the type, should ensure that employees are safe, environmentally healthy, and comfortable. One of the ways to achieve these criteria is by minimizing the mismatch between the office-design and the work processes (Mawson, 2002). More specifically, providing comfortable workstation, good lighting, low acoustic level, and peaceful aesthetics are among the environmental elements that are necessary for employees in almost any workplace (Jackson & Klein, 2009;

General Services Administration, 2011). However, despite knowing the importance of having a good office that contributes to the well-being, comfort, and performance of employees, the present situation indicates that the existing work environment is yet to move towards providing comfort, especially those concerning the noise level in office spaces (General Services Administration, 2011).

Acoustical distraction has been a concern since the open-plan office design was introduced (General Services Administration, 2011). In this setting, activities such as telephone conversation or communication between employees, meetings, and discussions are common and unavoidable. Yet, these activities are among the most contributing factors to noise in the office (Jensen, Arens, & Zagreus, 2005; Pejtersen, Allermann, Kritensen, & Poulsen, 2006). Since acoustic disturbance is a prominent but unresolved issue in an open-plan office, other variables that are likely to motivate and increase the performance of employees should be investigated to counterbalance the adverse effects of noise in this setting. On one hand, it might be unfeasible to address all problems associated with open-plan office design. On the other hand, it seems impractical to limit the degree of communication in the setting so that a minimum acoustic level is achieved. A reasonable approach, therefore, is to explore specific variables that can potentially improve the quality of the environment and provide comfort to the employees.

One of these variables is the use of nature sounds in offices as a mean to recover from mental fatigue and achieve psychological restoration. However, studies in the area of perceived psychological restoration at the workplace tend to focus heavily on the positive effects of visual natural environments, and very few studies were conducted exploring the use of natural auditory stimuli in the office settings (Jahncke, Eriksson, & Naula, 2015). Soundscape research showed that natural sounds

are typically perceived as pleasant (Brown & Muhar, 2004); thus, it is likely that natural auditory stimuli may have a similar effect on perceived psychological restoration and mental fatigue recovery as the visual stimuli (Alvarsson, Wiens, & Nilsson, 2010). The present study, therefore, examined if exposure to nature sounds in open-plan offices can positively influence perceived psychological restoration and improve cognitive performance.

## **1.2 SIGNIFICANCE OF THE STUDY**

This study offers two important contributions. First, it contributes towards a better understanding of how auditory stimuli, especially nature sounds, are related to the perception of psychological restoration and improvement of cognitive performance. This is achieved by providing empirical evidence from existing employees doing their daily work inside an actual open-plan office setting. Second, the study is of relevance to researchers as it expands the generalizability of the existing findings as the previous studies were built up upon Western samples and contexts. Reliance on findings from Western-centric work might not bring a holistic understanding of the restorative potential of nature sounds on employees. Therefore, further examination of the relationship between natural environments and performance in various contexts, cultures, and settings are warranted.

## **1.3 RESEARCH OBJECTIVES**

Two objectives were addressed in this study:

1. To examine the perceived psychological restoration of employees after they have been exposed to the presence of nature sounds.

2. To examine the level of cognitive performance of employees after they have been exposed to the presence of nature sounds.

#### **1.4 RESEARCH QUESTIONS**

Two research questions were addressed in this study:

1. How do employees perceive their level of psychological restoration after the exposure to the nature sounds?
2. In what way the cognitive performance of employees is affected by the exposure to nature sounds?

#### **1.5 DEFINITION OF TERMS**

This section outlines the definition of terms for variables investigated in this study.

##### **1.5.1 Open-Plan Office**

Conceptual definition: Open-plan office refers to an open workspace that is visually transparent, with areas divided by filing cabinets, screen, or moveable partition that function as the separator of an individual workspace (Marquardt, Veitch, & Charles, 2002; Roelofsen, 2008).

Operational definition: In this study, open-plan office is defined as an open room, with partition, tables, chairs, computers, and other office equipment with a number of people working in it.

##### **1.5.2 Open-Plan Office Noise**

Conceptual definition: Open-plan office noise has been conceptually defined as sounds produced by humans and machines in an office (Pan & Chan, 2007).

Operational definition: In this study, open-plan office noise is defined as sounds coming from two sources; namely, human-generated noise, such as people talking and phone conversation, and machine-generated noise, such as sounds produced by photocopier machine and phone ringing.

### **1.5.3 Nature Sounds**

Conceptual definition: This variable refers to the sounds that are produced by animals or non-biological sounds that come from natural landscape (Pijanowski et al., 2011).

Operational definition: Following the definition suggested by Pijanowski et al. (2011), nature sounds in this study refer to a combination of sounds produced by animals, such as birds and crickets chirping (biophony), and a combination of sounds produced by non-animals, such as water flowing and rain dropping (geophony).

### **1.5.4 Perceived Psychological Restoration**

Conceptual definition: Kaplan and Kaplan (1989) defined psychological restoration as a recovery process from the directed attention fatigue.

Operational definition: In this study, perceived psychological restoration is defined as the perception of employees on their recovery from depleted attention after the exposure to nature sounds while working as measured by Hartig, Korpela, Evans, and Gärling's (1997) 16-item Perceived Restorativeness Scale (see Appendix 1).

### **1.5.5 Cognitive Performance**

Conceptual definition: Cognitive performance is conceptually defined as one's observed performance in evaluating tasks that involve thinking, problem-solving, and multitasking (Purdey & Leifer, 2012).

Operational definition: In this study, cognitive performance is operationalized as the ability to do and to complete a task with minimum errors. The task, which involves error detection and correction in four texts, were given to the employees in every experimental condition that they were exposed to. The errors were in the forms of spelling, punctuation, and grammar (see Appendix 1).

## **1.6 CONCLUSION**

This chapter has highlighted the background of the research interest and the problem areas concerning the variables of the study. The significance of conducting the present study as well as the research objectives and the research questions to be answered have also been described. In the next chapter, a review of key literature on open-plan office, office noise, perceived psychological restoration, nature sounds, and cognitive performance are presented.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.0 INTRODUCTION**

This chapter firstly provides an overview of the variables of interest (i.e., open-plan office, office noise, perceived psychological restoration, nature sounds, and cognitive performance), including the justification for the inclusion of these variables in the study; and secondly highlights the gaps in the literature that warrant the need to conduct this study, this includes elaboration on how this study addressed these gaps. This discussion also considers how this study contributes to the existing knowledge in the field of Industrial and Organizational Psychology. This chapter then describes the theoretical and conceptual frameworks that guided the study's research questions and hypotheses, and finally, it ends with a summary of the review and conclusion.

#### **2.1 OVERVIEW OF THE VARIABLES OF THE PRESENT STUDY**

##### **2.1.1 Open-Plan Office**

Open-plan office is characterized as an open workspace that is visually transparent, with areas divided by filing cabinets, screen, or moveable partition that function as the separator of an individual workspace (Marquardt, Veitch, & Charles, 2002; Roelofsen, 2008). This setting is preferred by many organizations mainly because it offers three advantages. First, it requires small space, at minimum cost (Jackson & Klein, 2009; Koske & Kwasira, 2015; Marquardt, Veitch, & Charles, 2002; McGregor, 2015; Purdey & Leifer, 2012; Roelofsen, 2008); second, it improves collaboration and teamwork among employees (Danielsson, 2005; Ding, 2008; Koske & Kwasira, 2015;

Lee & Brand, 2005; Roelofsen, 2008); and third, it promotes information sharing among employees (General Services Administration, 2011; Roelofsen, 2008). In short, the open-plan office provides significant benefits to organizational operation as well as to employee performance and work relationship.

Despite the many advantages offered, the open-plan office layouts have their own drawbacks. For example, Roelofsen (2008), who investigated the effects of job performance in relation to open-plan office design, found that a massive amount of performance loss was due to the frequent communication between colleagues. Meanwhile, in a study that examined the relationship between the office environments, health status, and job satisfaction involving employees in seven office settings, Danielsson (2005) found that open-plan office setting recorded the highest level of job dissatisfaction, and the least in health status. These findings are also consistent with a recent study by Haapakangas, Hongisto, Hyona, and Keranen (2014), which reported that open-plan office setting could lead to job dissatisfaction and increased the incidence of sickness.

The unfavorable effects of open-plan office setting were established not only in cross-sectional but also in longitudinal studies. For example, in a six-month follow-up study that compared the effects of private and open-plan offices on employees' satisfaction, physical stress, co-workers' relationship, and perception on job performance, Brennan, Chugh, and Kline (2002) revealed that satisfaction and perceived performance decreased in the open-plan design as opposed to the private design. Another study by Rashid, Wineman, and Zimring (2009) also reported that job satisfaction and organizational commitment showed a decline as the result of being in the open-plan office setting.

From these studies, it can be concluded that, despite being a preferred office design, open-plan office could also lead to some negative effects, such as more frequent communication (Roelofsen, 2008), increased acoustical distraction (Danielsson, 2005; Haapakangas, Hongisto, Hyona, & Keranen, 2014), increased feelings of crowding, especially in areas with minimal privacy due to small and packed layout (Brennan, Chugh, & Kline, 2002; Creagh, 2013), as well as decline in job satisfaction and organizational commitment (Rashid, Wineman, & Zimring, 2009; Danielsson, 2005). Of all these issues, reports on acoustical distraction or noise at the workplace are considered to be the highest (Creagh, 2013; General Services Administration, 2011), and this variable is discussed in the next section.

### **2.1.2 Open-Plan Office Noise**

Noise is defined as an undesired sound (Roelofsen, 2008; Stansfeld & Matheson, 2003). Noise within an office setting may originate from human, machine, impact, and background (Pan & Chan, 2007). Several criteria and standards were developed to set an acceptable noise level in a wide range of settings, including offices. For example, a noise level of 50 dBA is commonly used as a criterion for noise in a standard open-plan office (Venetjoki, Tuomaala, Keskinen, & Hongisto, 2006). Another criterion that is frequently used to measure the level of noise is the International Standard ISO 3382-3 (ISO, 2012), which yields an index known as Speech Transmission Index (STI). This standard regards a setting with STI of 0.30 and below as having a low-disturbance level, while 0.50 and above as having a high-disturbance zone. In a situation where conversations are unavoidable, Roelofsen (2008) recommended that the level of background noise is kept at 45 dBA to decrease the negative effect of such noise. All these criteria and standards suggest that although the level of noise might

vary depending on the nature of work and office, it is important to ensure that the noise level in an office is maintained at the low disturbance level as noise has been shown to have negative effects on people.

A growing body of research has documented the adverse effects of noise. In their review, Stansfeld and Matheson (2003) found that undesirable sound could influence people's quality of life as it disturbs sleep, health, motivation to work, and performance in both adults and children. The study required participants to complete attention-requiring-tasks in three noise conditions (i.e., quiet, intermittent, and continuous), Jackson and Klein (2009) reported that those who were exposed to high level of noise were most negatively affected. According to them, the intermittent noise was regarded as the most disturbing and led to the highest decrement in attention. In some cases, however, the effects of noise depend on the type of task given. Venetjoki, Tuomaala, Keskinen, and Hongisto (2006), whose study examined the effects of speech sound, mask speech, and continuous noise on the performance of proofreading, reading comprehension, and computer-based tasks, found that while the productivity of proofreading tasks was reduced by the speech sound, the performance of the other two tasks remain undistracted.

In another line of study, Jahncke et al. (2011) investigated the effects of noise and office environment on cognition, emotion, and physiological states of employees. Using university students as simulated workers, Jahncke and colleagues exposed the participants first to a high and low level of noise while doing work in the simulated office, and then to one of the restorative conditions (i.e.; movie of a river with sound, sound of river only, silence, and office noise) after finishing the work. Their results showed that participants who were exposed to high noise office condition recalled fewer words, reported to be more tired, and experienced a decreased in motivation as