A grounded theory approach to investigate the perceived soundscape of open-plan offices

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ABSTRACT

This paper presents the findings of a user focused soundscape survey, that took place in a visual task based and a computational task based open-plan office spaces. Aim of this study was to conduct a grounded theory survey which captures individuals' subjective response to the soundscape and creating a conceptual framework in the end. In order to achieve this goal, acoustical environment and sound sources were identified. In-situ measurements of sound levels ($LAeq$) and simulations, prepared by Odeon Room Acoustics Software 13.10 Combined, were used to explore the acoustical environment of the office spaces. Grounded Theory was used as the main research method to create a conceptual soundscape framework, and to reveal employees perception of the soundscape of their work environment. As part of grounded theory, semi-structured interviews were conducted with forty-nine employees from both types of offices. The results showed how the task at hand were affected by the sound environment and employees' characteristics. Sound that were not expected or out of context and those that interfere with the concentration demanding tasks caused a negative interpretation of the soundscape. Due to this, employees' adopted coping methods such as, accepting and habituating, intervening to the sound source, or putting on headphones to isolate themselves from the soundscape. It was discovered during the interviews that employees were concerned with silence as much as they were concerned with the noise. Employees expressed that the sound of keyboard and mouse means that they are working at that moment, there are other people around, and they are not working alone, or not working overtime.

1. Introduction

Open-plan offices are one of the most popular workspace layouts as they provide increased net usable area, higher occupant density, ease of reconfiguration and most importantly improved communication and interaction between employees, [1,2]. However there is no empirical evidence showing that open plan layout will increase task performance. In fact they are associated with lack of visual and acoustic privacy, and uncontrolled sounds levels, which can cause significant decrease in task performance and workplace satisfaction [1–4]. These factors may also cause disturbance in various activities employees are performing, which can make them change their work strategy or behave differently by adopting coping methods [1]. An appropriate acoustical design of an open office should involve a sufficient control of speech. In order to achieve this, several factors need to be considered, such as; absorbers on ceilings, walls, and furniture, high screens and storage units, distance between workstations, enclosure of workstations, and the use of artificial masking sound [4,5]. An extensive literature exists regarding the physical environment of open offices. Among all the parameters

that affect an indoor physical environment, the acoustical environment and uncontrolled sound levels are the most frequent source of dissatisfaction [1–4,6]. Dissatisfaction with the sound environment can have a negative effect on a variety of factors such as health, wellbeing, job satisfaction, productivity, etc.

A number of studies have focused on the associations between these factors and lack of speech privacy. Researchers identified that prolonged noise exposure and lack of speech privacy caused a major decrease in the workplace satisfaction [2,6,7]. Satisfaction with the work environment and overall job satisfaction are some of the most important aspects of an office environment. Regarding this, Frontczak and his colleagues carried out a very extensive study and revealed that highest level of satisfaction is observed for ease of communication and amount of light [7].

Another challenge of the open offices is the fact that they can contain variety of different sound sources. Numerous studies have focused on investigating the types of sounds and their effects on employees. Studies have shown that both intelligible and unintelligible sounds are major sources of annoyance. [8]. Brocolini et. al., found that

intelligible speech causes significant decreases on task performance for serial memory tasks and also observed that masking sound does not have any effect on performance. [9]. Pierrette et. al. also found a decrease in task performance caused by intelligible conversations, followed by unintelligible conversations and phone ringtones [8]. Aside from this, an interesting finding regarding open office task performance has been discovered by Seddigh and colleagues [10]. Their results indicate that a decrease in performance in concentration demanding tasks is observed for employees working in cell type offices when compared to those working in small and medium sized office spaces [10]. The authors discuss that due to the high amount of irrelevant stimuli found in open offices, occupants might have a stronger incentive to develop methods of coping with them [10]. Zhang and colleagues also focused on the impact of noise in open office environments [4]. A large portion of employees (ranging from 30% to 50%) thoughts that various sound sources inside and outside the office environment were either disturbing or very disturbing.

Based on the literature, the sound environment of an open office space has a crucial influence on occupants' wellbeing, performance, health and satisfaction. However, various recent studies suggest that when it comes to perception of the sound environments, the objective measurements may not be enough [11,12]. Understanding the perception of the sound environment requires a different approach, which is concerned with individuals' subjective response to their sonic environment, and various elements within that environment. In order to achieve this goal, this paper will report the findings of a qualitative indoor soundscape research.

1.1. The soundscape concept

Soundscape approach was introduced by Schafer, a composer and a scholar, who was concerned with the radical changes in the auditory environment of modern society [13]. According to Schafer, the only time modern society pays significant attention to this matter was either when it is too loud or when there is a technological innovation [14]. Most common methods employed by the authorities regarding the changing auditory environment were to determine the maximum sound levels (SPL) through guidelines and legislations. Yet these methods fails to reflect the subjective human perception of the auditory environment which is crucial to explore and evaluate [15].

In 2014, ISO 12913-1 published the first part of the soundscape standard which provided its clear definition and a conceptual framework [16]. According to this, the term "soundscape" is defined as "the acoustic environment perceived or experienced and/or understood by a person or people, in context" [16]. With this regard, the recent consensus on the soundscape approach suggests that soundscape exists through human perception. The framework described by the ISO 12913-1 explains the process of perceiving or experiencing the soundscape through seven general concepts and their relationships (Fig. 1). These concepts are; context, sound sources, acoustic environment, auditory sensation, interpretation of the auditory sensation, responses and outcomes [16]. The framework acknowledged the context as a key element. Sound sources compose the soundscape which is modified by the acoustics environment (absorption, reflection, etc.). Context can influence the soundscape through, auditory sensation, interpretation of the auditory sensation and the response to the acoustic environment [16]. It can be said that the soundscape approach is concerned with individuals' or society's understanding and perception of the acoustic environment and the meaning associated with it, rather than the sound energy. [11,14,15,17,18].

Regardless of its recent popularity, soundscape still lacks a well-accepted evaluation method and much of the case studies are limited to urban spaces. Over the decade, researchers proposed various methods to explore and evaluate soundscapes. Some of the researchers used the soundwalk method to investigate the urban soundscapes [12,19–21], while various others used binaural recordings and psychoacoustic measurements [18,22,23]. More subjective evaluations of soundscape consists of analysing questionnaires, interviews, semantic differential scales [6,12,19,21,24–26]. Indoor soundscape on the other hand, not only lack a well-accepted evaluation method but also greatly lack case studies.

Every space has its own unique sound environment; soundscapes, the underlying sound sources and the acoustical requirement differences [27–30] This requirements would vary and more complex in indoor spaces, since auditory perception will differ due to the interfering factors such as building geometries, finishing materials, activities and reverberation [17,31]. Indoor spaces have much more complex acoustical environments than outdoor spaces and any kind of indoor space (metro stations, high schools, restaurants, opera-concert halls, hospitals, etc.) should be involved in soundscape studies [32–34]. For these reasons, the classification of sound sources should be elaborated with different case studies that consider all types of acoustic environments and in addition to the outdoor soundscape studies, indoor soundscape also needs to be investigated. Using a qualitative approach can provide individuals' subjective response to the indoor soundscape clearly.

1.2. Grounded theory method

Grounded Theory (GT) is a less frequently used but a more user-centred method that can systematically analyse individual's subjective perception of the soundscape. Its inventors, Barney Glaser and Anselm Strauss, described GT as" The discovery of theory from data" [35]. This approach is favoured by numerous researchers to analyse the qualitative data traceably, systematically, and due to its ability of providing an in-depth information about the phenomenon [12,17,32]. GT's multi-disciplinary and systematic approach generates an inductive theory about the field of study. Using the GT in a soundscape research will provide an insight on individual's subjective perception of the auditory environment. The method achieves this through face to face interviews, constant comparative method, theoretical sampling, systematic coding,
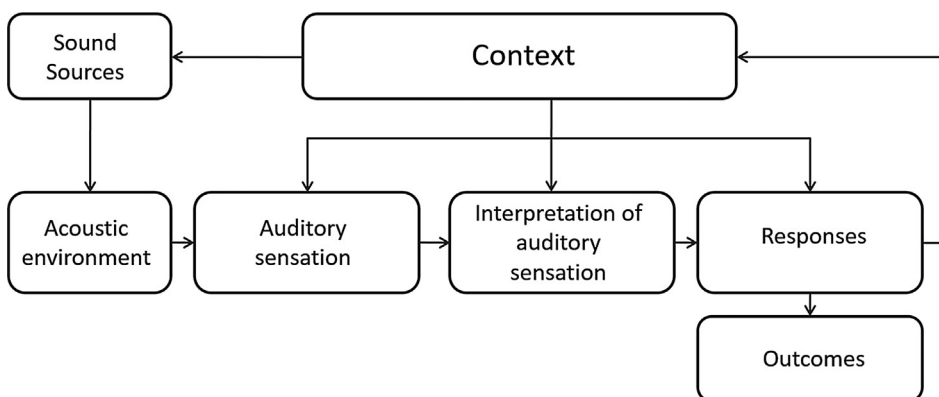
Fig. 1. Soundscape Framework created by ISO12913-1 [16].