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To cite this article: H C Indrani *et al* 2021 *J. Phys.: Conf. Ser.* **1896** 012014

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Conceptual model of soundscape perception based on working behaviour in open-plan offices

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Abstract. The open-plan office is one of the most popular and preferred workspace arrangement options for employers today. The results of research in western countries show that listeners' perceptions of the soundscape in open-plan offices are negative, due to reduced visual and acoustic privacy and uncontrolled sound levels. This can cause a significant decrease in work comfort and productivity. Several researchers have provided acoustic design solutions by performing adequate speech control through several solutions such as creating spacing between workstations, the use of acoustic dampening materials, insulation between workstations, and application of a noise masking system. The phenomenon of adopting an open-plan office has also hit offices in big cities in the world, including in Indonesia. The purpose of this paper is to further examine listeners' perceptions of the soundscape in the case of open-plan offices in the local environment because the results are indicated to be different from similar cases in western countries, given the peculiarities of employee work behaviour which are influenced by individual experiences and social effects in the local environment are also different. For this reason, a comprehensive literature review method is needed that aims to investigate the relationship between soundscape perceptions and working behaviour in open-plan offices in the local environment and then to create an integrated conceptual model so that further researchers can evaluate the research related to these problems.

1. Introduction

At present, office buildings (workplace) in major cities in the world use an open-plan system rather than the conventional type. The open-plan system is one of the most popular workspace layouts and is favoured by stakeholders because the workspace is more spacious, the interior design is more modern and refreshing, there is a need for an efficient workspace, a higher worker density, an easy reconfiguration and layout modification. Most importantly, it improves the communication and interaction among employees so that job involvement becomes greater [1]. However, the results of research in western countries show that the open-plan workspace system can cause problems related to acoustic landscaping (soundscape) due to lack of visual and acoustic privacy and uncontrolled sound levels, which can cause a significant decrease in performance and employee satisfaction outcomes [2]. The obstacles that often occur are bad soundscape conditions due to bad privacy conversations, concentration difficulty due to noises that disturb the employees. The noises disturb cognitive performance, especially when reading and remembering activities. The circulating voices of people in the corridor between workstations and the ringing of the telephone are often the cause of annoying



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distraction. The decline in cognitive performance reaches its peak, not because of the strength of the voices, but when the voice of other people's conversations is clear. Dissatisfaction with the negative impact of the soundscape on the workspace can have a negative effect on various factors such as health (physical and mental), well-being, job satisfaction, and productivity [3]. Among all negative parameters, indoor soundscape with uncontrolled sound level is the most frequent source of dissatisfaction [4]. Several researchers have provided acoustic design solutions by performing adequate speech control through several solutions such as (1) creating spacing between workstations as part of the workspace layout design; (2) the use of acoustic damping materials on ceilings and walls; (3) insulation between workstations; and (4) application of a noise masking system (noise perfume) [5], [6], [7], [8].

The phenomenon of adopting an open-plan workspace has also hit offices in big cities in the world, including in Indonesia. Researchers need to further investigate how listeners perceive the soundscape conditions in the case of open-plan offices, especially in big cities like Indonesia. The results are indicated to be different from similar cases in western countries, given that the peculiarities of employee work behaviours which are influenced by individual experiences and social effects in the local environment are also different.

For this reason, there is a need to conduct a comprehensive literature study that aims to investigate and draw an in-depth understanding of the relationship between soundscape perceptions and worker behaviour in open-plan offices in the local environment and then to create an integrated conceptual model so that further researchers can evaluate the research related to the problem. The results of literature study are needed to answer the following specific research questions: (1) What are the factors that positively influence the perceptions of the soundscape and the behaviour of workers in open-plan offices in the local environment? (2) What conceptual model that can be used to evaluate a case study research related to the perception of the soundscape and the worker's behaviour in open-plan offices in the local environment?

2. Methodology

The literature review is one type of research methodology that is most often used in cross-disciplinary research [9]. Researchers usually use literature reviews as a means of answering specific research questions about a topic [10]. Initially, this study involves a series of literature reviews on several peer-reviewed journals, articles, book chapters, and open access content in English to build a basis for research findings using a systematic review approach.

The systematic review approach aims to summarize and evaluate research fields and is the most accurate and thorough approach in collecting articles so that there is a certainty that all relevant data have been covered [11]. This approach is very useful for answering the first research question. Then, it proceeds with an integrative review approach, where the review is truly integrated and contributing to developing a new conceptual model. The integrative review approach is a very effective way to cover a wider range of subject areas and topics than systematic reviews can handle [10] [11] by reviewing several reference books. This approach is useful for answering the second research question.

Data extraction and collection methods were selected before the review process, including selecting a search tool, the appropriate database, and deciding the inclusion and exclusion criteria [11]. The 2015 PRISMA-P (Preferred Reporting Items for Systematic reviews and Meta-Analyses Protocol) Guidelines are considered the most recent reference for the performance of literature review and data reporting. PRISMA-P 2015 is a series of evidence-based items that are used as a general framework for reporting a systematic review to ensure the comprehensiveness of reporting.

This study went through 3 (three) stages to form the body of the text, namely (1) identifying and collecting data, (2) classifying, and (3) analyzing the data. The first stage is carried out by collecting data from several previous studies. Databases are taken from Elsevier Science Direct, Taylor and Francis Online, SAGE Journals, SpringerOpen, DOAJ, and Emerald to search for electronic records related to studies using the keywords soundscape, human perception, user behaviour, and open-plan offices mentioned in the title or abstract. The second stage is done by screening and determining the criteria of eligibility using related keywords based on 3 (three) main criteria, namely the year of publication, journal reputation, and article citations. The time limit for the articles under consideration was taken from 1998-2021 (23 years) when the articles related to the soundscape were published, thus providing

an opportunity to discuss the evolutionary development of the study and to keep up with changes over time.

The reputation of the journal also plays an important role in selecting superior, high-quality manuscripts. This study uses highly cited articles and the most highly cited articles to maximize the quality of the research. The third stage is analyzing articles that have been collected, especially for studies included in the qualitative synthesis. Then, they are distributed into each classification to facilitate further analysis, so that this study can produce a conceptual model that is useful for future researchers in evaluating case studies related to soundscape perceptions based on working behaviour in open-plan offices in the local environment.

2.1. Literature search strategy and criteria of eligibility

The literature search strategy was carried out to obtain studies related to the soundscape, human perception, user behaviour and open-plan offices. More specifically, the inclusion criteria being considered were field studies in open-plan office areas and studies assessing factors that influence the perceptions of the indoor soundscape of building users with normal hearing. An interesting perceptual aspect is related to the identification of noise sources that are considered and liked/disliked in open-plan offices and the positive character of soundscapes in the building space.

The aspects of soundscape and human perception that are not used are (1) the case of soundscape perception in the deaf; (2) speech perception, on the general perception of the acoustic environment, in addition to the problem of speech clarity; (3) a case of vibration perception that is of concern to acoustics in the air; (4) the problem of sleep disorders due to noise which is a concern in daily activities.

2.2. Data extraction

Several aspects that were relevant to the research question and stated according to the inclusion criteria were taken from the selected studies for further discussion. There are various metrics found in the studied studies, data synthesis is only taken through a quality effect model so that quantitative meta-analysis is not used. Thus, a qualitative approach was used to summarize the results and answer the research questions.

The various information taken from each selected study includes (1) type of study (field study, survey, soundscape assessment); (2) the type of sound studied that is relevant to perception; (3) sound level used to predict perceptual results (4) soundscape data collection method; (5) types of physiological measurements; (6) types of questions asked to building occupants; (7) classifications that affect the soundscape perception and occupant behaviour.

2.3. Database search results

The database search results obtained were then exported to Mendeley and 499 articles (review articles, research articles, encyclopedia, and book chapters) and reference books were collected, where studies related to the soundscape, human perception, user behaviour, and open-plan offices have been published (1998-2021). A total of 201 articles were removed due to duplication, non-English or irrelevance. Then, as many as 298 articles were collected related to the discussed topics. Furthermore, the titles or abstracts of articles that do not meet the selection criteria for indoor acoustic environments, in this case, open-plan offices, are also removed (such as rural acoustic environments, wilderness acoustic environments, underwater acoustic environments, clinical environments, and hospital soundscapes) so that 18 articles were collected for further study.

A total of 13 complete text articles and reference books relevant to the research question were taken (5 articles were excluded because they did not meet the eligibility criteria) which were included in the qualitative synthesis review and analyzed manually in terms of methods and content. A flow chart showing the number of studies was screened and assessed for eligibility and those included in the review are presented in Figure 1.

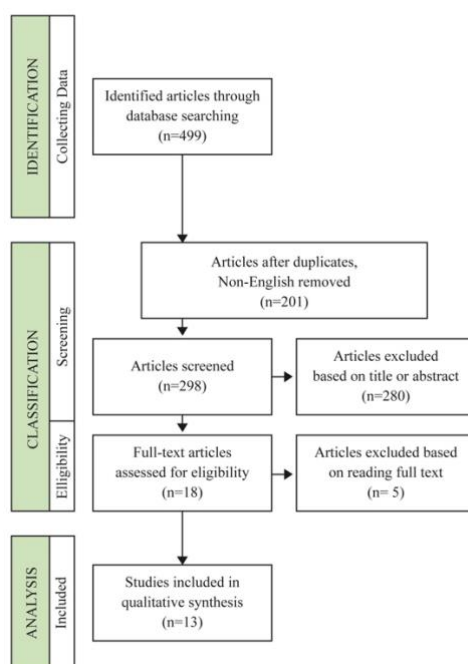


Figure 1. Systematic review with the flow of information through several phases.

3. Discussion

Soundscape can exist through human perception of the local acoustic environment. Studies to understand soundscape perceptions require a more concerned approach to subjective responses to their acoustic environment and the various elements in that environment.

A subjective assessment includes the habitual characteristics of users in an environment. This variable includes the user's contextual experience including demographic data, space usage, and psychological factors. Integrated study of these three factors is the key to clearly understanding the approach of indoor soundscape [12], [13], [14]. Demographic factor is one of the important factors that can influence the contextual experiences. Demographic factors consisting of individual characteristics and socio-cultural characteristics are the initial basis for classifying several population samples in a case study. The individual characteristics of several population samples may reflect basic information about individual participants in a population sample in a case study, where physiological characteristics as the main focus is considered to be related to gender and age. Meanwhile, the socio-cultural characteristics reflect individual backgrounds and behaviour patterns in a population sample in a case study. The most common research related to socio-cultural characteristics is about one's education, cultural background, and habits. The space usage can also influence contextual experiences. The frequency of space usage relates to the user as the source and receiver of sound at the same time and how it integrates with space. Thus, attitude, behaviour, and situation in the room are very important because they will show the relationship between humans and their environment. Besides, one's preferences are important in terms of space usage because a space will not be used if that space is not liked. The analysis of space usage preferences for acoustic comfort shows a very significant correlation, so it must be evaluated as the first step. Time spent for using space (minutes or hours depending on the case study) is also an important factor in the assessment of sound disturbance and acoustic comfort as it can affect a user's perception and experience. Apart from the two factors above, psychological factors also influence contextual experiences. Understanding of the processes that occur in the human mind is needed. The processes start with expectations, continues with perception, and ends with results (feelings, thoughts) as reactions (behaviour-oriented actions). This suggests that psychological processes can be used as a starting point for clarifying reactions. These three things can be obtained through the results of interviews (open, semi-structured, or structured), surveys (questionnaires) designed in combination with their previous experience of types of space and how they shape their knowledge of the space.

In evaluating the soundscape, it is also necessary to pay attention to four important factors [15] (1) human activity and behavior (whether they feel they have control over their soundscape environment and whether the sound produced in the soundscape meets their expectations regarding social behaviour and place norms); (2) attention (the soundscape can be evaluated as negative if the foreground sound requires more allocation of attention because it is louder and unpredictable, or vice versa as positive if the sound blends harmoniously); (3) soundscape information for listeners (soundscape can stimulate listeners to explore and understand the environment, but the information must be true or expected); (4) pay attention to individual differences among listeners (individual preferences for soundscapes and memory associations can influence the evaluation of soundscapes; emotionally charged associations are considered very influential, and memory of past soundscapes can significantly influence current evaluations).

Soundscape perception is a very complex phenomenon because it is possible to have positive and negative perceptions simultaneously of the acoustic environment so that soundscape perception depends on expectations, preferences, mood, recent activity [16, 17], and user activities in space [18]. To evaluate the acoustic environment and how it can be perceived, a user's expectations regarding the physical environment must be understood first [19]. Expectations are a series of events that are anticipated before something happens or a strong belief that something will happen. Expectations of a place and its soundscape can affect the perception of the soundscape, where the expectations of the soundscape are based on previous individual experiences. Soundscape preferences are very context-dependent. They consist of [20] (1) location (what is liked in one place can be different from that in other places, even in one place at different times); (2) dimensions of the physical environment (wind factor, temperature, lighting, traffic); (3) personal activities of a person at a location (whether alone or in a company) and activities of other people in that place; (4) dimensions of the social environment, including regional characteristics and social norms concerning places, activities, and behaviour; (5) personal dimension, including motivation to be in a place, doing an activity, and individual background; (6) space characteristics. Soundscape assessment will require analysis and identification of context because it will influence the determination of preferences. Thus, the soundscape perception is related to seven general concepts namely context, sound sources, acoustic environment, auditory sensation, interpretation of auditory sensations, and responses [21].

In evaluating the soundscape, occupants as building users must be the focal point and the evaluation process related to the surrounding factors must be carried out in a structured manner. Therefore, contextual conditions, a listener's attention, knowledge, and past experiences of building occupants [22], [23], all act as effective variables.

Behavioural studies emphasize that human cultural backgrounds such as life views, beliefs, values, and norms will determine a person's behaviour, which is reflected in the way of life and the role he chooses in society. The social and cultural context determines the human activity system [24]. This suggests that culture as an important variable is often used and researched in many disciplines. The way of life and the system of activities will determine the type and space for these activities. The spatial approach framework from the aspect of behaviour emphasizes the human agency factor, namely the decision of each human being or a group of humans to formulate their view of the world, formulate shared values of life, and to describe them in daily living habits as outlined in the system of activity and system of setting [24], [25]. In other words, the motive for human activity can not only be understood mechanically as a response to economic or biological stimuli, but it contains meanings and symbols that have been agreed upon among certain human groups. This approach emphasizes that the aspects of human psychology and the culture of a society will determine the form of activity and its space. Thus, the study of architecture and behaviour needs to learn the relationship between human background factors, values, culture, and lifestyle because they can cause different perceptions for each person.

To build a conceptual model, Table 1 reviews the classification resulting from 13 previous studies by recording the soundscape perception variables as the dependent variable, the worker's behaviour variable as the independent variable, and the work culture variable as a moderating variable that will influence workers' behaviour in perceiving soundscapes in the local environment. These variables are proposed to be operational variables for soundscape research related to the working behaviour in open-plan offices in the local environment in the future.

Table 1. Summary of the review studies (n=13).

Reviewed Articles	Classification	Operational Variables		
		Soundscape Perception	Occupant Behaviour	Work Culture
<ul style="list-style-type: none"> ▪ Yorukoglu and Kang [12], [13] ▪ Aburawis and Yorukoglu [14] 	<ul style="list-style-type: none"> ▪ Demographical factors (individual characteristics, socio-cultural aspects) ▪ Space usage factors (preferences, frequency of usage, time spent) ▪ Psychological factors (expectation, perception, reaction) 			
<ul style="list-style-type: none"> ▪ Davies et al. [15] 	<ul style="list-style-type: none"> ▪ Human activity and behaviour ▪ Attention ▪ Soundscape information ▪ Individual differences 			
<ul style="list-style-type: none"> ▪ Lindborg [16] ▪ Lindborg [17] ▪ Lindborg [18] ▪ Bruce and Davies [19] ▪ Brown et al. [20] 	<ul style="list-style-type: none"> ▪ Expectation ▪ Preferences ▪ Mood ▪ Recent activities 	<ol style="list-style-type: none"> 1. Sonic 2. Spatial 	<ol style="list-style-type: none"> 1. Temporal 2. Psychological 3. Behavioural 4. Personal 	<ol style="list-style-type: none"> 1. Life views 2. Values 3. Lifestyle
<ul style="list-style-type: none"> ▪ Kang and Schulte-Fortkamp [21] 	<ul style="list-style-type: none"> ▪ Context ▪ Sound sources ▪ Acoustic environment ▪ Auditory sensation ▪ Interpretation of auditory sensations ▪ Responses 			
<ul style="list-style-type: none"> ▪ Marry and Defrance [22] ▪ Schulte-Fortkamp [23] 	<ul style="list-style-type: none"> ▪ Contextual conditions ▪ Listener's attention ▪ Knowledge ▪ Past experiences 			
<ul style="list-style-type: none"> ▪ Rapoport [24] ▪ Rapoport [25] 	<ul style="list-style-type: none"> ▪ Life views ▪ Beliefs ▪ Social values ▪ Norms ▪ Culture ▪ Lifestyle 			

The factors resulting from the studies of Yorukoglu and Kang [12] [13] and Aburawis and Yorukoglu [14] have been re-adapted and re-arranged to be integrated with work culture variables to improve understanding and facilitate an appropriate and efficient evaluation tool so that it can help further researchers to get results more accurately in evaluating the soundscape perception based on working behaviour in open-plan offices in the local environment as shown in Figure 2.

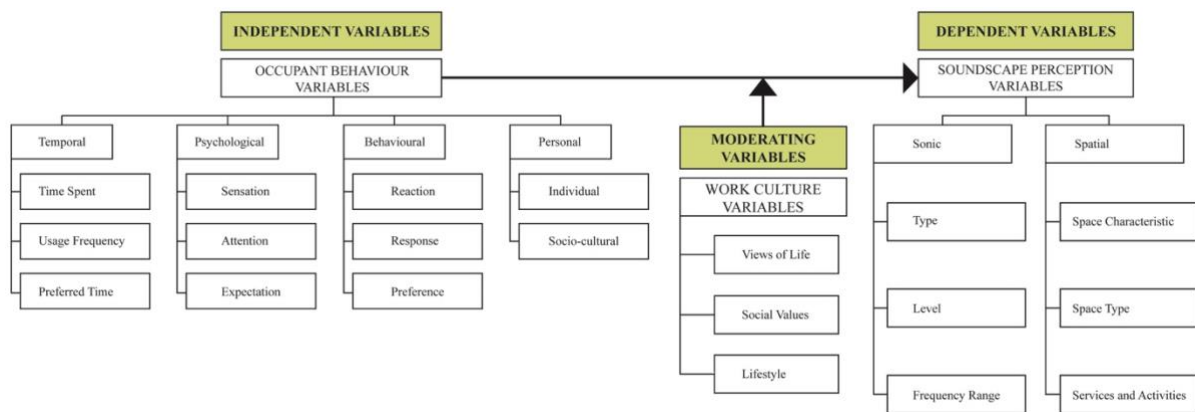


Figure 2. The conceptual model of soundscape perception based on working behaviour in open-plan offices in the local environment.

4. Conclusion

A review of several related literatures has been carried out to identify and develop various classifications of factors that positively influence soundscape perceptions and working behaviour in open-plan offices in the local environment. A working behaviour that is derived from the culture of the people is more general (global) and abstract, making it difficult to connect culture and environment. It is necessary to see culture through certain components of the environment that support the cultural component. Social variables are very helpful for expressing culture, namely through life views, values, and way of life (lifestyle) to see patterns of thought, actions, and behaviour of individuals or groups of people in certain environments.

Culture and habits in the life pattern of western and Indonesia society show that there are differences, especially in terms of life, where Indonesian people emphasize more on humans and religions (emotional-spiritual), so that they uphold religious values and customs, by emphasizing the values of kinship and upholding family norms, through harmony and respect, both of which are basic principles of the social life of the Indonesian people. The way of life (lifestyle) tends to be communal (collectivism), so that they always see themselves as part of a group, harmony, expressing sympathy and empathy for others. This causes the mindset, actions, and working behaviour of western society to be different from those of Indonesian society which tends to be very socially related, to be able to forge more complex relationships, to have high solidarity, prioritizing togetherness and connection, cooperation, tolerance, close friendship among colleagues, and to feel more comfortable with colleagues. By looking at the behaviour of Indonesian society, it can be ascertained that work culture variables can influence workers' behaviour in perceiving the acoustic environment around them so that the results are indicated differently from those in western countries.

A conceptual model has been proposed by including the moderating variables of work culture into the operational variables of the research which include (1) life views, (2) social values, and (3) lifestyle. This conceptual model can be used by future researchers in evaluating a case study related to soundscape perception based on working behaviour in open-plan offices in the local environment.

Acknowledgements

The authors would like to thank Petra Christian University for funding this research and the anonymous reviewers for their insightful suggestion and careful reading of the manuscript.

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