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A REVIEW OF THE PSYCHOLOGICAL EFFECT OF ENVIRONMENTAL SOUND

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Abstract:

Few studies have stressed how access to high-quality acoustic environment affects wellbeing, quality of life, and environmental health. The acoustic environment influenced by noise pollution reduces the restorative effect generated by the natural environment. Noise policies which focus on noise level as a determinant of wanted and unwanted sounds are inadequate to control the acoustic quality of the environment. Therefore, this paper aims to identify the psychological effect of environmental sound and the direction of study for environmental sound research from 1993 to 2020. Review works of literature were identified through multiple interdisciplinary health, environmental, and urban planning databases in available open access journals. The focus of the study will look into keywords of "environmental sound", "noise", “acoustic environment” and "mental health". The review showed that previous study focused on the negative effect of noise and noise mitigation methods through the noise level controls in the guidelines. On the other hand, recent reviews continue to discuss the impact of noise further and add on a positive view of the psychological effect of environmental sound. Noise mitigation methods also focused on enhancing positive sounds and methods for a more comprehensive study of the environmental sound.

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Keywords:

Noise, Environmental Sound, Acoustic Environment, Mental Health

Introduction

According to the World Health Organization (WHO) (2004), mental health is defined as a state of wellbeing in which every individual realizes his or her potential, can cope with the everyday stresses of life, can work productively and fruitfully, and can contribute to his or her community. In short, it refers to a state of emotional and psychological wellbeing allowing someone to function in society and cope with the demands of daily living. Smith et al. (2001) reports a statistically significant relationship between noise exposure and depression and cognitive failures. Still, several other studies in the field showed inconsistent results on the relationship between noise and mental health (Lercher et al., 2003).

There has been a continuing interest in the psychological effects of environmental sounds over the last ten years since the most recent review of environmental noise and mental health by Kamp and Davies (2008). Psychological effect of environmental sounds refers to the behaviours of the community such as elevated or decrease in stress, annoyance, and anxiety. The adverse health effects of environmental noise on people and communities have been thoroughly investigated by many researchers particularly in cities where excessive exposure to noise has been proved to account for a wide range of psychophysical detrimental health effects (Aletta et al., 2018).

Environmental sounds are commonly defined as non-speech and non-musical sounds occurring in the everyday environment (Gygi and Shafiro, 2007). However, when a sound becomes too loud and unpleasant, they are often treated as noise. Many studies have examined whether environmental noise exposure is associated with psychiatric hospital admission, medication use, psychological symptoms, and psychiatric disorder measured by questionnaires and structured interviews. The effect of noise on physical health has been studied significantly in the past decade. Also, there are increasing studies on the perceptual responses towards environmental sound and noise, where research began investigating positive effects of sounds and applying them in restoring the environment.

Reducing environmental noise in cities can be beneficial in terms of economic and social benefits, but it does not always lead to improved wellbeing and quality of life where in some cases, loudness may be desirable in some contexts (Andringa et al., 2013; Aletta et al., 2018). The current management of environmental sound by noise level as the focus of environmental acoustics regulations and policies worldwide may not necessarily lead to improved quality of life (Kang et al., 2016). Therefore, there is a need to better understand the psychological impact of environmental sounds by considering both the negative aspects of noise and the positive aspects of environmental sounds for a more comprehensive sound management approach. This review attempts to identify the psychological effects of environmental sound and the direction of study of environmental sound research.

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Methodology

The review is carried out through multiple open-accessed sources ranging from the interdisciplinary health and environmental databases and urban planning databases of Web of Science, Scopus, and Science Direct from the institution subscriptions, and Google Scholar's freely accessible web search published journals. Selected keywords of previous research papers were also identified and used to extract further related online articles. Keywords such as "Environmental Sound", "Mental Health", "Noise" have been used to query information from the databases. Sourced article titles and abstracts were screened for relevance to the aims and scope of the review paper. Duplicates of articles were rejected. Then, full texts of the chosen articles were downloaded and analyzed to be included in the final review process.

This review describes studies relating to environmental sound and mental health reported since the last review in the field was carried out in 2008. The current research will be reviewed, findings in the field will be outlined, and suggestions will be made for the directions of future research. The review process is described in the flowchart (see Figure 1).

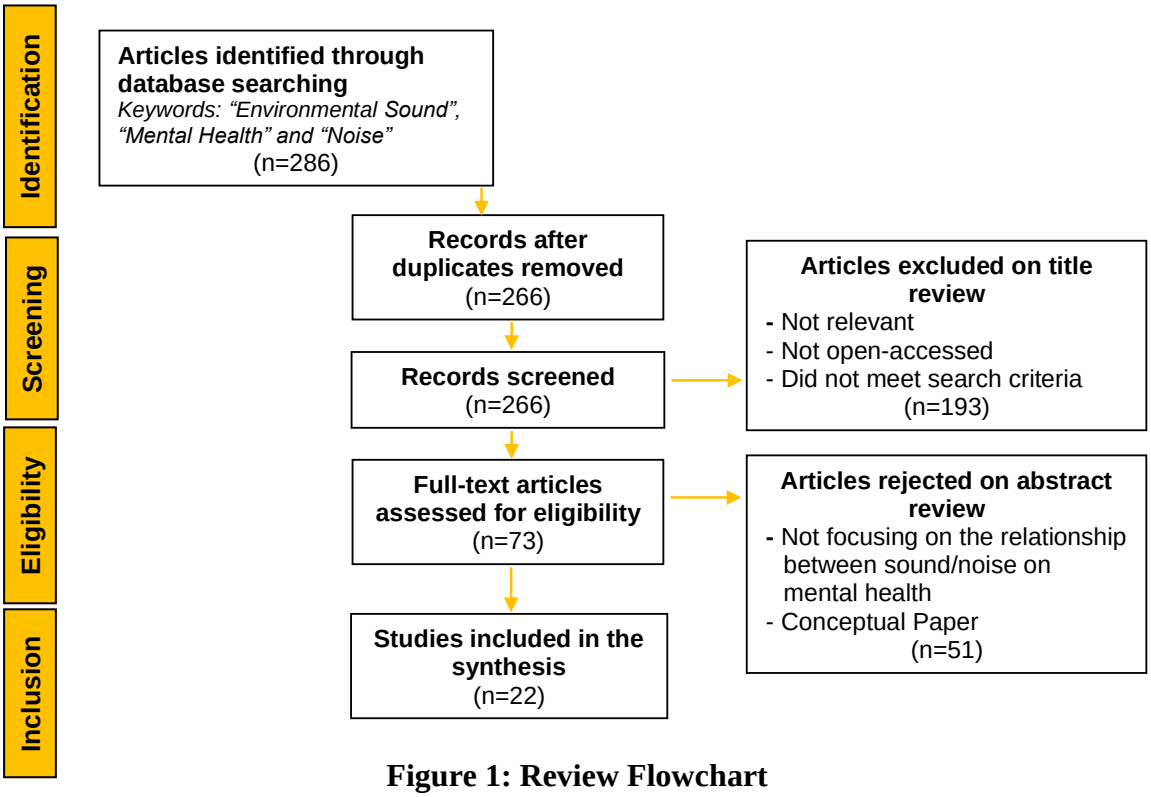

Figure 1: Review Flowchart

Main Results

Psychological Effects of Environmental Noise and Sound

While there are already a few reviews on environmental noise effect on mental health (Standsfield et al., 2000; Clark and Paunovic, 2018), this review adds to the discussion by looking into the psychological effect of environmental sounds both positively and negatively. Research papers for the review are categorized into the following categories for discussion.

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Negative Psychological Effect of Environmental Noise

Previous studies have investigated the effects of sound in terms of environmental noise, which can be defined as the unwanted or harmful outdoor sound created by human activity. According to Stansfield et al. (2000) who reviewed research regarding noise and mental health studies, showed that before the year 1993, many different mental health outcomes were examined in relation to environmental noises from the transportation sectors – aircraft noises and roads traffics. However, the results were then inconsistent on the relationship between environmental noise and mental health effects but were more consistent with less severe psychological symptoms. Studies during those periods were measured by noise exposure which links noise levels with health issues. It is also supported by a review by Jobs (1996) who produced a model of the connections between noise, community reactions, modifiers, and health effects at the end of his review, where evidence in the review suggests a complex relationship on the effects of noise on health through the reaction towards noise (see Figure 2).

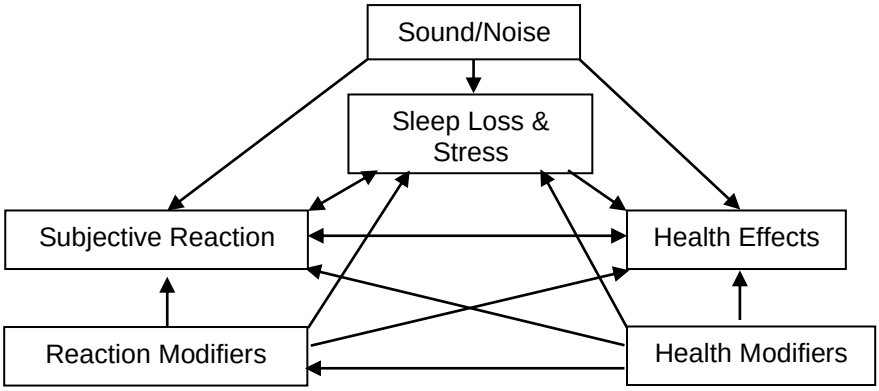

Figure 2: A Model of The Connections Between Noise, Community Reaction, Modifiers, and Health Effects

Source: (Job,1996)

Medical indexes were used to assess the health symptoms, such as a questionnaire study using the Todai Health Index adapted to the Japanese context based on the Cornell Medical Index (Ito et al., 1994; Hiramatsu et al., 1997). To measure quality of life and mental health symptoms, studies used the SF36 mental component score, World Health Organisation Quality of Life Questionnaire (WHOQOL-BREF), and measures from the Diagnostic and Statistical Manual of Mental Disorders (DSM) (Nissenbaum et al., 2012; Feder et al., 2015; Rudolph et al., 2019).

Studies also looked into the relationship between noise exposure and self-reported noise sensitivity in determining psychiatric symptoms (Nivison and Endresen, 1993). Research suggests that environmental noise exposure, especially those at higher levels, is related to mental health symptoms. Still, it is supported with little evidence that it has a severe psychological effect.

According to Moudon (2009), the psychosocial effects of sound levels on health include annoyance, reduced performance quality, and increased levels of aggressive behaviour. A review by the WHO environmental noise guidelines for the European region summarized a lack of evidence for noise effects across studies covering the quality of life, wellbeing, and

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mental health domains. Noise effects have not yet been studied robustly for different noise sources except the review from Dreger et al. (2015), who studied the influence of different environmental noises at home and related it with children's mental health symptoms.

Other studies which looked into the negative psychological effect of environmental sound often associate it with traffic noise or wind turbine noises (Feder et al., 2015; Di. et al., 2018; Nissenbaum et al., 2012) (see Table 1). A general conclusion of the findings suggests that environmental noise research often looks into the sound pressure level of these noises and how they influence people's behaviours. While previous research studied the role of noise sensitivity in environmental noise towards mental health, Schreckenberg et al. (2010) argued that noise sensitivity of an individual is a more specific and reliable predictor of the responses to noise towards physical health but not with reported mental health.

Positive Psychological Effect of Environmental Noise

The most recent review by Kamp and Davies (2008) showed new directions into studies of positive and restorative effects of quiet areas. They looked into evidence of mental health effects due to environmental noise in both adults and children, with evidence suggesting that there is no direct association between environmental noise and mental health. The main variables in these studies include sound level and mental health symptoms assessed through questionnaires. However, noise annoyance is often the mediator between the impact of noise on health, where those with a lower noise annoyance tolerance are seen to be impacted more psychologically.

There has been an increase in the studies of environmental sounds, not only focusing on the negative impact of noise but also the positive effect of environmental sound on mental health (Gygi and Shafiro, 2008; Alvarsson et al., 2010, Thorne and Shepherd, 2013; and Abbott et al., 2016) (see Table 1). Studies began looking into the application of environmental sound research. It investigates the importance of a quiet environment and more discussion on multidisciplinary fields on how natural sounds restore mental health and aids in stress recovery.

The health-related measure for the studies includes Physiological Measurement (SCL) to measure stress level, Restorativeness Scale, and self-reported wellbeing and health conditions (Alvarsson et al., 2010; Booi and Berg, 2012; Shepherd et al., 2013; and Trudeau et al., 2020). Studies in the review also included annoyance-related measures to interpret the psychological outcomes of the positive environmental sounds (Kamp and Davies, 2008; Booi and Berg, 2012; and Shepherd et al., 2013).

Research of environmental sounds not only focused on the positive effects of the sounds but also the application of noise masking through enhancing other positive sounds. Cerwen (2017) mentioned that a variation in the sounds people hear leads them to seek out their favourite environment depending on their preference, mood, and other factors and suggests using these environmental sounds to formulate design interventions in noise-exposed areas. Instead of just looking into reducing the noise level of the sounds, many research also investigates other methods of enhancing the environmental sounds that positively affect mental health. Therefore, it has been suggested that people’s opportunity to access quiet and natural places can be enhanced by improving the environmental sound quality and leads to psychological benefits.

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Table 1: Summary of Research on Environmental Noise and Sound

Author (Year)	Study Focus	Parameters of study	Findings
Negative Psychological Effect of Environmental Noise			
Standsfeld et al. (1993) Job (1996)	Noise level and health	• Noise sensitivity • Psychiatric disorder	While evidence shows that there have been consistent results for less severe health issues, psychological symptoms but majority of the results show that there is no explicit link between noise and health. Lack of evidence that noise exposure predicted psychiatric disorder, but results show that noise sensitivity is associated with psychiatric disorder
Standsfeld et al. (2000)	Noise exposure and quality of life	• Association of mental health symptoms and noise levels • Noise and mental ill-health in children	Noise sensitivity does not moderate the effect of noise on psychiatric disorder but does predict future psychiatric disorder. Environmental noise exposure relates to mental health symptoms but with little evidence that it has a serious effect. Need for improving measurement of noise sensitivity and annoyance
Schreckenberg et al. (2010)	Role of noise sensitivity towards environmental stressors and mental health	• Noise sensitivity • Self-reported physical and mental health	Noise sensitivity can be used to predict the response towards noise but not on how people perceive the environmental quality.
Nissenbaum et al. (2012)	Effect of industrial wind turbine noise on sleep and health	• Distance to wind turbine • Pittsburgh Sleep Quality Index • Epworth Sleepiness Scales • SF36 Mental Component Score	Noise emission from turbines impacts mental health, and current regulation is insufficient to protect those living near industrial wind turbines
Dreger et al. (2015)	Influence of different environmental noise source at children's homes on incident mental health problems	• Noise source • Noise exposure • Noise annoyance • Strengths and Difficulties Questionnaire	Exposure to noise at children home is associated with mental health problems such as emotional symptoms, conduct problems and hyperactivity
Feder et al. (2015)	Association between exposure to	• Quality of life • Sound Pressure Level	Quality of life scores using WHOQOL-BREF unrelated to wind turbine noise levels

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	wind turbine noise		
Hammersen et al. (2016)	Environmental Noise Annoyance and Mental Health in Adults	• Noise annoyance • Mental Health	High noise annoyance is associated with impaired mental health which varies with the source of the environmental noise
Di et al. (2018)	Quality of urban acoustic environment according to the functions of the area	• Sound level (Traffic propagation model)	Quality of urban acoustic environment was moderate during daytime and better at night and will influence the normal work and life of people
Rudolph et al. (2019)	Environmental noise and sleep and mental health outcomes in adolescents	• Day-night average sound levels • Sleep outcomes • Lifetime mental health DSM diagnoses	Consistency in the association of residence in high noise area and later bedtimes but not with the association of mental health disorders
Positive Psychological Effects of Environmental Sound			
Kamp and Davies (2008)	Mental health effects of environmental sound in adults and children	• Role of noise sensitivity • Importance of quiet in mental restoration	New evidence suggests that there is no direct association between environmental noise and mental health with noise annoyance as the mediator
Gygi and Shafiro (2008)	Progress of environmental sound research	• Studying meaningful sound • Application of environmental sound research • Noise control and design of acoustic environment	Effect of context on perception of individual sounds is under-explored but there is an increase in clinical application of environmental sounds. Research direction to look into exploring perceptual and acoustic properties of environmental sounds and the positive psychological effect of acoustic environment of specific sound inventories.
Alvarsson et al. (2010)	Physiological stress recovery of nature sound and noise	• Sound pressure level • Physiological Measurements (SCL)	Nature sounds facilitate recovery from stress.
Booi and Berg (2012)	Need for Quietness	• Quietness • Self-reported health condition	People with good health have a lower need for quietness
Thorne and Shepherd (2013)	Concept of quiet as environmental value of	• Sound level • Quality of life	Quiet sound environment is related to wellbeing and character of sound within an environment.

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	amenity and wellbeing from a legislative context		
Shepherd et al. (2013)	Quiet Areas and Health-Related Quality of Life	• Noise annoyance • Self-reported wellbeing and health condition	Quiet soundscapes facilitate restoration, and/or impede insult to health.
Abott et al. (2016)	Influence of natural sounds on attention restoration	• Type of sound (Natural/ Anthropogenic) • Cognitive performance	Natural sound facilitates attention restoration as compared to those in no sound or control condition.
Trudeau et al. (2020)	The Effect of Water Features on Soundscape Assessment in a Montreal Public Space	• Soundscape • Restorativeness scale • Perceived Loudness	Significant interaction effect between water feature and design of space, particularly on ratings of chaotic and loud.

Discussion

Psychological Effect of Environmental Sound

Studies on the negative psychological effect of environmental sounds often relates it to annoyance, reduced performance quality and increase in aggressive behaviours. Adverse psychological effects often associate the term noise with traffic noise, airports, or wind turbine noises (Feder et al., 2015; Di. et al., 2018; Nissenbaum et al., 2012). Findings also suggested that noise level of these noises influences people's behaviour while there are some who argued that noise sensitivity is a more reliable predictor to the response of noise with physical health and not with mental health. Although there is no significant evidence showing that environmental noise results in the prevalence of mental illness, it influences a person psychologically through an increase in annoyance where unwanted sounds can trigger anxiety or increase in stress level.

On the other hand, environmental sound from natural soundscapes shows evidence of positive psychological benefits in terms of the restoration of mental health, attention, and stress recovery. Positive soundscapes were associated with faster stress-recovery processes in laboratory experiments, and better self-reported health conditions in large-scale surveys (Aletta et al., 2018). Studies on the positive effect of environmental sounds also highlights the importance for an access to quiet and natural places where it leads to high psychological benefits. These studies also focus on methods of enhancing positively perceived sounds and the application of noise masking from environmental sounds.

Direction of Study

The increasing interest in environmental noise and its mitigation result from urbanization, where noise regulations investigate high sound levels from transportation and industries below guideline values. However, research looking into the character of the acoustic environment by

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Yang and Kang (2005), Axelsson et al. (2014), and Aletta and Kang (2015) debates that noise mitigation methods through the reduction of the sound level may not necessarily create a high-quality environment.

The negative effect of noise is consistently studied throughout the years. However, more recent studies focused on noise annoyance and noise sensitivity and added a more comprehensive understanding of the psychological effects from all noise sources. Studies on environmental noise also investigate better predicting and mapping the influence of environmental noise on the community (Di et al., 2018).

On the other hand, the studies on environmental sounds also move in the direction of applying the knowledge of positive sounds' impact on mental health towards encouraging the urban community's wellbeing and mental health (Cerwen, 2017). It begins by investigating the benefits of natural sounds in the restoration of mental health and further investigates the application of these positive and pleasant sounds in noise masking and enhancing the acoustic environment. It can be concluded that research on environmental sound understands that managing the sound level of the noise itself is not sufficient in enhancing the environment, but the addition of environmental sounds yields a better result in managing the issue of noise (see Figure 3).

The suggestion is supported by a study by Moscoso et al. (2018) (see Figure 4), who described the evolution of study in environmental sound. Studies in 2010 began to investigate the study of human perception of sound within psychological research and are followed by the evolution of terms with a deeper understanding of perception and influence of sound on humans in the year 2013-2014. The research has broadened involving environmental patterns and ecological impacts of noise in the years 2014 to 2015.

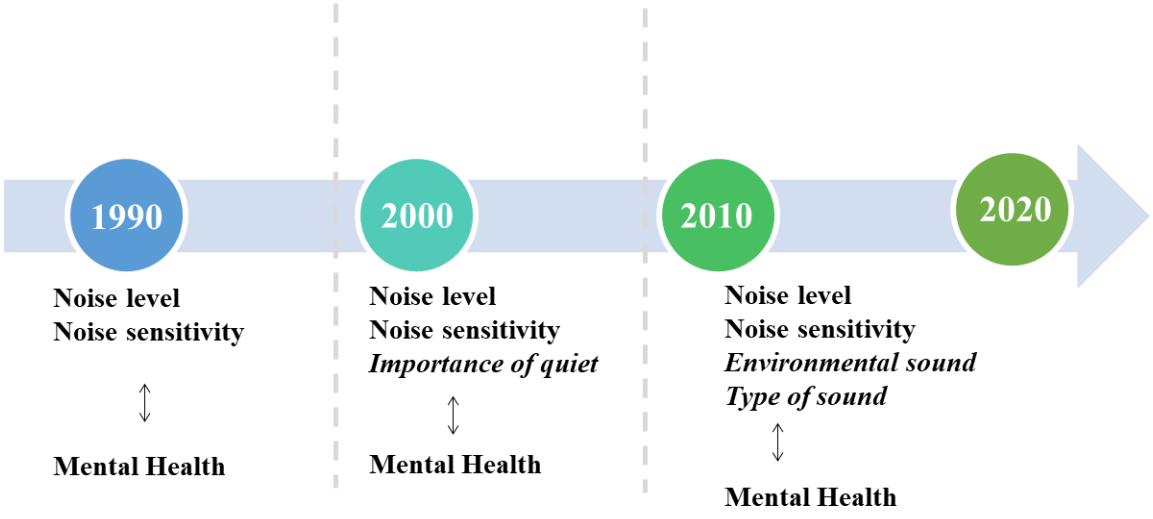

Figure 3: Direction of Study of Environmental Sound

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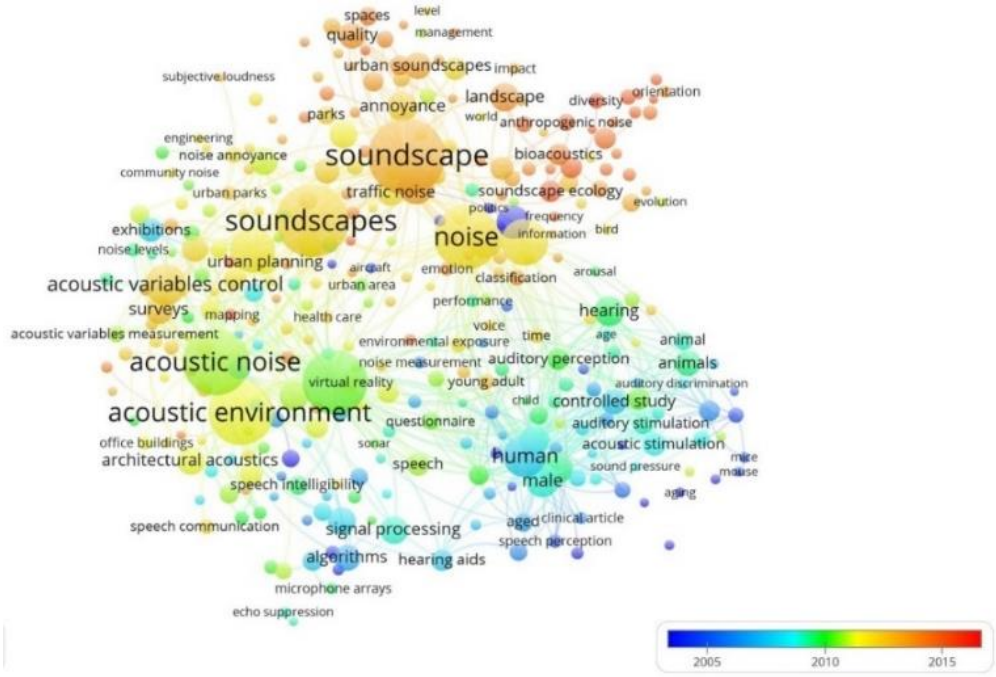

Figure 4: Temporal Network of Environmental Sound Research
Source: (Moscoso et al., 2018)

Management of Environmental Sound

The evolvement of environmental sound studies can also be seen through the changes in the management of environmental sounds. The traditional method of managing environmental sounds is noise level control, also known as environmental noise management. This "Environmental Noise Directive" (END) applied in the European Union is used as a reference to assess and manage environmental noise where the noise is dealt with its sources. The focus of the report is on the unwanted sound sources and their effects on the community.

However, recent researchers looked into new environmental sound approaches by making full use of positive environmental sounds to promote wellbeing and reduce the impact of unwanted sounds (Aletta and Kang., 2015) (see Table 2). Kang et al. (2016) also emphasized the need to shift from a noise control policy towards a multidisciplinary approach by focusing on how people experience the environment. Several types of maps with noise data, urban and architectural data, and perception description can be used to comprehensively analyse the acoustic environment instead of just measuring through noise maps (Vogiatziz and Rémy, 2018; Lacey et al., 2019).

In short, the management of environmental sounds has evolved from the use of noise control by physical measurement to also incorporating humanity and social science, focusing on how people experience the environment. This is in line with the direction of study for environmental sounds to include preserving the positive sounds people enjoy.

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Table 2 Summary of Research on Environmental Sound Management

Author (Year)	Study Focus	Parameters of study	Findings
Dumyahn, and Pijanowski, (2011)	Environmental sound should be managed as a common pool resource	• Multiple soundscape user • Difficulty of exclusion • Subtractability and degradation	Management of soundscape
Aletta and Kang, (2015)	Management of areas of good environmental noise quality	• Noise Mapping • Sound Level measurement • Soundscape Approach	Different methods used to triangulate acoustic environment
Vogiatziz and Rémy (2018)	Multidisciplinary approach to analysing environmental noise data with urban and architectural data and perception description	• Urban Typology Map • Strategic Noise Map • Spatio-Acoustic Typology Map • Map of Predominant Use • Sound Signal and Sound Mark Map • Sound Identity Map	Environmental Sound should take a multidisciplinary approach in analysing the sound environment for a comprehensive plan as shown in the Sound Environmental Action Plan (SEAP)
Lacey et al., (2019)	Noise transformation to treat noise as design material	• Noise management	Noise transformation as new method in noise management by chancing the perceptual impact of noise to make it less annoying
Brambilla et al. (2020)	Smartphone-based participatory soundscape mapping for a more sustainable acoustic environment	• Soundscape Mapping • Noise Mapping	Potential, benefits and drawbacks of participatory noise monitoring in noise and soundscape mapping applications

Limitation

The reviewed literature showed the impact and direction of study for environmental sounds on mental health. While the results showed a change in the pattern of environmental sound research and noise management approaches, conclusions cannot be drawn regarding the psychological effects of all sources of environmental sounds. This is because the studies performed are often targeted at the effects of specific sound sources. Therefore, a more comprehensive understanding of the influences of environmental sounds should be undertaken to discuss and address what is considered noise and how environmental sounds affect the community's wellbeing.

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Scope For Further Research

With the increasing urbanization and emphasis on the importance of mental health and wellbeing, the approach towards environmental sound and mental health is looking to be more comprehensive. It investigates both the positive and negative impact of environmental sound. Studies into the positive and restorative effect of the quiet areas are recommended and in urbanized areas clustered with high noise pollution. Future research should also investigate methods of identifying and predicting areas with positive sounds in better managing and preserving the quality of the area. In terms of urban planning, this review has contributed to the direction of sound management where more emphasis is to consider the perception of the community on their preference of sound and measures to cope with the increasing environmental noise. With the focus of environmental planning, cities can be planned in terms of how land uses influences sounds, and to create better spaces for restoration and wellbeing of the community.

Conclusion

This review has found evidence that there are both positive and negative psychological effects caused by environmental sounds. While the negative effect comes from annoyance towards noises, the positive effects can be extracted from the restoration of natural environmental sounds. Management approach of environmental sound should therefore take into consideration of both the effects for a comprehensive solution in dealing with noises and wellbeing. However, findings of the review are limited to the low number of studies of the effects of sound over all types of sound sources as studies on negative effect focus on road traffic noises and industries. The review showed that while the effects of environmental noises have significantly been studied, future studies should focus on the effects of sounds from all sources to have a comprehensive understanding of the topic. Moreover, future studies should also compare the management of environmental sounds across the various methods suggested with a greater number of case studies to test the effectiveness of the methods in better managing environmental noise and enhancing the positive environmental sounds for the community's wellbeing.

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