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Exploring the interplay of psychoacoustic parameters and microphone selection in soundscape recording: a comprehensive review and practical guide

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ABSTRACT

This research explores the intricate relationship between psychoacoustic parameters and microphone selection for soundscape recording, drawing inspiration from foundational concepts introduced by Schafer and Cage. Motivated by the need to comprehend the influence of psychoacoustic dimensions—specifically frequency, sound intensity, and time—on the choice of microphones for capturing auditory environments, the study adopts Liu and Kang's systematic literature review method. This approach entails a comprehensive analysis of diverse sources to identify knowledge gaps and establish a robust theoretical foundation. The primary aim is to offer practical guidance to professionals and researchers in the field of soundscape recording. Findings underscore the efficacy of a cardioid condenser stereo microphone that aligns with the analyzed psychoacoustic parameters. This study not only contributes to advancing practices in soundscape recording but also deepens our understanding of the intricate dynamics between soundscape, psychoacoustics, and sound recording devices. By recognizing the significance of Liu and Kang's methodology, the research serves as a foundation for future experimental designs and field testing. Acknowledging Liu and Kang's contributions, the study highlights the pivotal role of their systematic literature review method in shaping the research landscape, underscoring the importance of methodological rigor in advancing our understanding of complex auditory phenomena. This research provides a comprehensive overview of the nuanced relationship between psychoacoustic parameters and microphone selection for soundscape recording, contributing to the broader discourse in the field of auditory research. The implications of this research extend to the field of sound environment recording and psychoacoustics, providing a deeper understanding, improving recording quality, developing practical guidelines, encouraging recording technology innovation, and contributing to the field of psychoacoustics.

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1. Introduction

The perception of a soundscape is generally understood as a collection of sounds. Fatally, if this perception is validated as a fixed principle, it will miss perception of the meaning of the soundscape itself. Sugiato explains that a soundscape is not just a collection of sounds, but also how these sounds are interpreted by the people who hear them. The soundscape of a place can be influenced by a variety of factors, including the physical environment, the time of day, and the activities of the people who are present., which can take part in the context of sound in an environment with a soundscape which an adventurous concept of ideas in a non-visual form, namely an acoustic landscape for the ear [1]. The concept of soundscape created by Scahfer has an auditive phenomenon that comes from sound pollution as stated by Nakagawa that the concept of soundscape created by Schafer to overcome the existence of sound pollution when he taught at Simon Fraser University, Vancouver, Canada in the 1960s [2]. He was disturbed by the sound of workers who were busy building and he protested the sound. He was forced to ask himself about the noisy sound. As a musician, he has always thought about sound, including noise [3]. Schafer says that we must first learn how to listen to a soundscape, just as we listen to music. Schafer's confidence and sense of self-worth as a musician in the face of the soundscape are encapsulated in those words [3] .Schafer's idea dates back to the 1950s, which was the idea of contemporary composer John Cage, who asked the question "what is music?", with his most famous work 4:33. John Cage's work 4:33 he performed only silently on stage with a duration of 4 minutes 33 seconds John Cage said the music in the work 4:33 was the sound found around such as coughing sounds, footsteps, passing vehicles and others.

Suka Hardjana argues that sound as nature is very suggestive of humans where humans cannot escape from nature as well as humans cannot escape from sound [4]. From the phenomenon of John Cage 4:33 has implications for what elements of a soundscape, as the sense of hearing cannot be closed at will there are no earlobes when we sleep, our perception of sound is the last door that is closed and also the first to open when we wake up [5]. This phenomenon can be analogized to the human ear being an auditive sensory device that never stops recording sound [6]. To examine the underlying or hidden relationships between these variables, the structure of all soundscape parameters was examined. Since all soundscape parameters are measured by scales, in order to analyze the relationship between the compositional parameters of the soundscape, and between each of its compositional parameters and the physical and psychoacoustic parameters [7]. Recording for soundscapes requires different handling than recording musical instruments in general. This is because individual specimens are difficult to isolate for recording purposes and also because the sounds produced generally have a complex frequency structure or broadband sound, with harmonics often rising into the ultrasonic range. The selection of the required sound recording device by reviewing the acoustics and microphone specifications needs to be reviewed. The use of recording techniques to produce an audio sampling has many methods but still adjusts to the target audio to be recorded which boils down to the characteristics as according to Hong *et al.,* that recording techniques affect the characteristics of the recording results, namely how the timbre aspects and spatial quality [8]. Utilizing spatial recording provides an opportunity to gain a unique perspective on the space being studied. For example, when conducting questionnaires in a large urban park, the initial session could involve capturing a spatial recording within the area being surveyed [9].

Psychoacoustic findings that soundscapes have sound parameters that can be measured with a stepwise analysis conducted between each soundscape composition parameter and physical and psychoacoustic parameters, to test the extent to which the dependent variable can be explained by the independent variable [10]. So that a draft measure appears with audio frequency parameters and also the hardness of sound with units of dB (decibel). From these findings there will be parameters that can be correlated to the selection of the type of sound recording device, namely a microphone that can capture spatial space and sound hardness .in accordance with the parameters contained in the findings by Liu & Kang, to select the type of microphone that can record a soundscape by reviewing how psychoacoustic parameters make the researcher's interest to study the selection of efficient microphone types for soundscape in accordance with Liu & Kang's psychoacoustic parameters [7]. The research on exploring the interplay of psychoacoustic parameters and microphone selection in soundscape recording is crucial for advancing the field of audio recording and sound perception. By investigating how psychoacoustic dimensions such as frequency, sound intensity, and time influence the choice of microphones for capturing auditory environments. This study bridges the gap between theoretical concepts and practical applications in sound recording. The significance of this research lies in its potential to enhance the efficiency and effectiveness of sound recording practices, providing valuable guidance to professionals and researchers in optimizing their recording setups for capturing immersive soundscapes. Additionally, by deepening our understanding of the intricate dynamics between soundscape, psychoacoustics, and sound recording devices, this study contributes to the broader domain of psychoacoustic research and sets a foundation for future experimental designs and field testing.

2. Method

This research centers on how the recording device can capture the soundscape with the parameters of Liu & Kang's psychoacoustic findings [7]. This research adopts the literature review method, to dissect how psychoacoustic aspects, sound recording devices, and soundscape. Literature review is one of the literature searches and research by reading various books, journals, and other publications related to the research topic, to produce a writing regarding a particular topic or issue [11]. This approach involves the development of a research protocol, a comprehensive literature search, an evaluation of the quality of the literature, and an integrated analysis of the findings. The literature review is carried out with a systematic and critical approach to understand the progress of previous research, identify knowledge gaps, and provide a solid theoretical basis for the research to be carried out [12]. The data collection technique in this research uses the documentation study method, where researchers collect references in the form of books and journals related to the research theme. Furthermore, the author analyzed the books and journals to get conclusions related to the research theme. The literature study was analyzed using five key elements: search, assessment, synthesis, analysis, and presentation [13]. All key elements were elaborated to find a complete set of narrative findings and discussion, see Fig. 1.

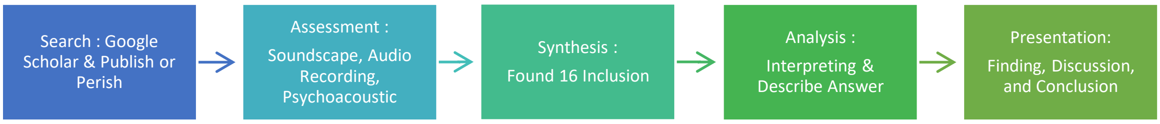

Fig 1. Key Element of Data Analysis

Literature was collected through article searches on Google Scholar and Publish or Perish. The assessment was carried out by determining the inclusion criteria for research that included related keywords: soundscape, audio recording, psychoacoustics. The screening results in the assessment (synthesis) found 18 inclusion articles according to the predetermined criteria. The synthesis results state that research related to this research is still small and still needs comprehensive deepening. The 1 inclusion articles were analyzed to obtain important data related to the research which was then presented (presentation) to be elaborated as research findings and discussion.

3. Results and Discussion

3.1. Psychoacoustic Soundscape Parameters

The findings in psychoacoustic parameters in urban soundscapes in Liu & Kang's study psychoacoustic parameters have been confirmed to be of limited effectiveness [7]. The efficiency of finding characterizing soundscape quality is possibly due to the differentiation of individual auditory perspectives [14]. Soundscapes with specific psychoacoustic characteristics can be designed with different sound compositions in mind [15]. Various parameters that represent objective information about soundscapes, such as perceived loudness, occurrences of different sound categories, and the diversity index of soundscapes, in relation to landscape features [7], [16], [17]. These parameters are referred to as soundscape composition parameters, which are used to objectively describe the presence of different sound sources in a soundscape. The fundamental hypothesis was that the objective presence of soundscapes in terms of the composition of different sound sources, or the socalled objective soundscape information, remains consistent regardless of how people perceive the soundscapes [10]. The minimum sound level required for individuals to detect tones varies among people. Through numerous measurements and statistical analysis, an average value can be determined to represent typical behavior. It is worth noting that this threshold of hearing, commonly known as the absolute threshold of hearing, significantly depends on the frequency of the sound.

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This is highlighting the importance of understanding psychoacoustic parameters, such as the threshold of hearing, which can vary among individuals and are crucial in the study of human perception of sound [18]. This relationship may only exist in urban parks of the same type as those examined in the case study sites, generally with normal sound pressure levels of 40 dB to 80 dB [10]. With the dB measurement in the normal limit of sound hardness up to 80 dB for normal pressure is requires an approach to psychoacoustic frequencies that have parameters with a match that the human ear can accept [19]. According to Ballou humans can hear frequencies as low as 20 Hz and as high as 20,000 Hz (20 kHz) in the psychoacoustic circuit, this is the deviation of air pressure from ambient atmospheric pressure when air pressure fluctuations have a frequency between 20 Hz and 20 kHz, it will be heard by humans [20]. So there is a graph which has two parameters, namely the sound hardness in units of dB and frequency in units of Hz in this Fig 2.

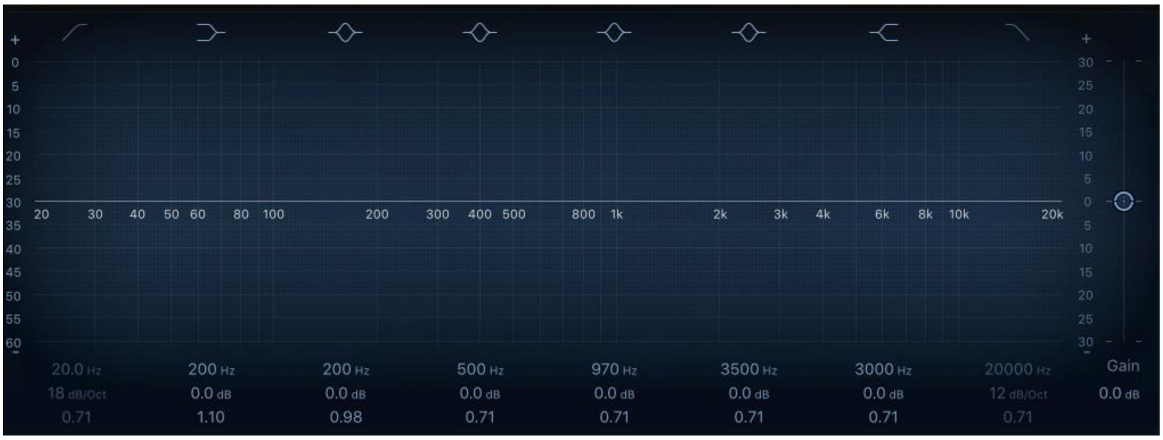

Fig 2. Graph of Frequency in Digital Equalizer *(Logic Pro X)*

There are different measurements, apart from sound hardness and audio frequency parameters, used in the psychoacoustic measurements by Liu & Kang [7] as shown in the Fig. 3.

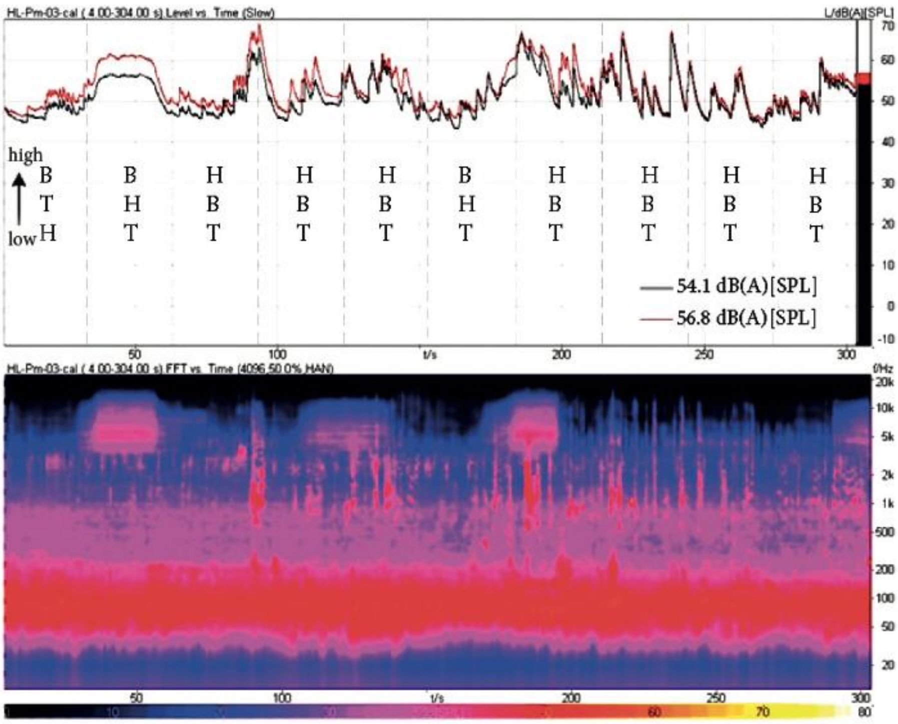

Fig 3. Graph of Frequency, Energy Form, and Time [7]

From this parameter there are measurements based on audio frequency, sound hardness, and time in frequency information where in Fig. 3 the first graph table has the letters H (Human Sound), B (Biologycal Sound), T (Traffic Sound). Human sounds generally include various types of sounds such as conversations, children's shouts, footsteps, and other physical activities produced by humans. The frequency range of human sounds typically ranges from 500 Hz to 2 kHz, although it can vary depending on the type of human activity producing the sound. The human voice is often considered a prominent or dominant sound in a park environment because of its high social and emotional value. Human voices can provide a sense of social life and human activities around the park, and can influence the overall perception of the sound environment. Biological sounds include bird sounds, dog sounds, and insect sounds that are part of the natural ecosystem in the city park. Bird sounds generally have a frequency range between 1.5 kHz to 2 kHz, while insect sounds tend to have higher frequencies, around 3 kHz to 10 kHz. Biological sounds provide a natural feel and biodiversity in the park environment, and can create a calm and harmonious atmosphere. Bird sounds and other natural sounds can provide a relaxing effect and connection with nature for park visitors, and improve the overall quality of the sound environment. Traffic noise includes motor vehicle noise, aircraft noise, and the noise of other transportation activities that contribute to noise around the park.

Traffic noise generally has a lower frequency range, specifically between 25 Hz and 200 Hz for motor vehicle noise. Traffic noise is often perceived as the dominant background noise and can be distracting in an urban or city environment. Traffic noise can affect the acoustic comfort and sustainability of the park environment, and can affect noise levels and noise pollution around the area. A soundscape is typically linked to a specific location, and the sounds within this location should be differentiated from those outside of it.The sound produced by local sources can vary in volume and direction depending on where the listener is situated, while sounds from sources outside this area, such as distant road traffic [21]. Description of recording time 00-304 seconds with units of S (Second), there are time parameters from 50 S to 300 S. Perceptual studies have shown that the detectability of brief acoustic signals is considerably enhanced by increasing their duration, as a consequence of the temporal summation of signal energy in the peripheral auditory system of receivers [22]. The field of acoustemology, for example, is concerned with recognising a location based on auditory experiences values need to be collected systematically and over certain periods of time, to observe the acoustic reflections of transformations as well as to have original forms of cultural sounds [23]. In terms of sound hardness with dB parameters, the sound with the lowest hardness is at 10 dB. In the second graph table where there is an energy graph in the frequency parameter 20Hz-20,000Hz, with the thickest energy thickness in the frequency 50Hz-200Hz. From the parameter graph in Fig. 2, it can be seen that a microphone is needed that can capture the dominant frequency from 50Hz-200Hz, with a minimum hardness of 10 dB and the highest hardness at 80 dB. Based on the two figurations above, it can be seen that the highest sound hardness distance is at 80 dB, and the lowest distance is 10 dB for the sound hardness parameter in the Fig. 4.

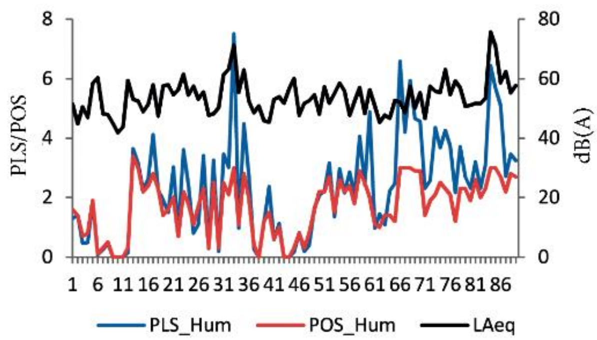

Fig 4. Graph of Sound Loudness and Time [7]

In Fig. 4 there are PLS (Perceived Loudness of Individual Sound), POS (Perceived Occurrences of Individual Sound), and LAeq (Level Equivalent Continuous Sound Level). PLS is the loudness of an individual sound, POS is a sound that has been categorized in a soundscape, and LAeq is a constant noise level that will produce the same total sound energy over a certain period [9]. Perceived Loudness of Individual Sound (PLS) refers to a human's subjective perception of the loudness or noise level of an individual sound or a specific category of sounds within a soundscape environment. It reflects the extent to which the sound sounds loud or tinny to the listener. PLS has an important role in understanding how different types of sounds or sound sources are perceived by listeners in a given environment. It enables an assessment of how those sounds contribute to the overall sound perception of the environment. PLS can be measured using subjective or objective scales, such as loudness scales or loudness measurement devices. PLS data can be used to analyze the relative contribution of different types of sounds to the overall loudness of the soundscape. Perceived Occurrences of Individual Sound (POS) refers to the frequency or occurrence of individual sounds or specific sound categories within the soundscape environment. POS reflects how often the sound occurs or is heard in a given period of time. POS has an important role in identifying the relative presence of different types of sounds within the soundscape. It can provide insight into the dominance of certain sounds and the pattern of sound presence over time. POS can be calculated based on the number of sound occurrences in a given time interval. POS data can be used to evaluate the relative distribution of different types of sounds and understand the patterns of sound presence in a soundscape environment.

LAeq (Level Equivalent Continuous Sound Level) is a standardized measure to describe the average noise level or sound intensity over a period of time. It refers to the noise level that would be produced by a constant sound of the same intensity over the same period of time. LAeq is used to provide an overview of the noise level or sound intensity in a particular environment over a period of time. It helps in evaluating the overall noise level of the environment. LAeq is measured in decibels (dB) and can be calculated for a specific period of time, such as an hour or a full day. LAeq data is used to compare noise levels between different locations or times within the soundscape environment. With a good understanding of PLS, POS and LAeq, soundscape researchers can better analyze and interpret sound data, as well as identify the relative contribution of different types of sound to the overall perception of sound in an acoustic environment. Conventionally, environmental noise policies are primarily centered on the energetic reduction of sound pressure levels (SPL) however, SPL indicators provide limited information on perceived acoustic comfort as it involves higher cognitive processes [8].

3.2. Microphone Types for Soundscape Recordings

Microphones have various types, the use of microphones as sound recording devices for soundscape requires a review of the distance of sound hardness. Microphones have types that can be adapted to the soundscape as according to Weekhout that there are three types of microphones that are commonly used, namely dynamic, condenser, and ribbon but in all microphones there are different polar patterns so that to capture specific spatial space and sound hardness requires the selection of microphones with the appropriate polar pattern [24]. Polar pattern is a pattern that determines sensitivity at different angles, choosing the right pattern can avoid unwanted sound sources from entering the audio signal, adjusting the mix between dry sound and room sound, or changing the frequency response, and affecting the distance effect polar pattern is also sometimes called pickup pattern [25]. Sensitivities for microphones may not be exactly comparable, as different manufacturers use different rating systems. Microphone output (in a sound field of a given intensity) is expressed in dB (decibels) compared to a reference level. Most reference levels are well above the microphone output level, so the resulting number in dB will be negative [8], [26]. Any microphone will produce distortion when overexcited by loud sound levels as according to Ballou that this is due to various factors in dynamic microphones, the coil can be pulled out of the magnetic field; in condensers, the internal amplifier can be squeezed [20]. Continuously loud or very loud sounds can permanently damage the diaphragm, thereby degrading performance at ordinary sound levels, in the case of ribbon microphones, the ribbon can be stretched out of shape, again causing serious performance degradation [27].

The selection of sound devices that can accommodate soundscape recording can be directed to a type of stereo condenser cardioid microphone. Stereo condenser cardioid microphones are used because they combine the effects of proximity and a little midrange along with a little lift

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in the high frequency range and wide spatial [26]. One of the microphones of this type is found in Zoom products, namely the H8 series, psychoacoustic measurements for soundscape can be compared with the Zoom H8 microphone specifications contained in the Table 1.

Tabel 1. Zoom H8 Specifications (Zoom Corporation, 2021)

Recording Formats	Zoom H-8	
	WAV Setting	
XY mic (XYH-6)	Supported Format	44.1/48/96kHz, 16/24-bit, mono/stereo, BWF format
	Maximum Simultaneous Recording Track	2 tracks (MIC IN, backup recording, 1-4, A, B, and LR)
	Mp3 Setting	
	Supported Format	128, 192, 320 kbps
	Maximum Simultaneous Recording Track	2 tracks

Table 1 shows, media cards that conform to the SD/SDHC/SDXC standard function as memory cards in devices such as cameras or voice recorders. The XY microphone (XYH-6) in this device is a directional microphone type, which means that it is able to capture sound from a specific direction. The sensitivity of the microphone reaches -41 dB at a frequency of 1 kHz at 1 Pa, measuring the microphone's response to sound pressure. The microphone's Input Gain setting range is from -∞ to 46.5 dB, allowing how strong the signal picked up by the microphone can be set. The microphone is capable of handling a maximum sound pressure of up to 136 dB SPL without experiencing distortion. Additionally, the mini stereo MIC/LINE IN jack on this device has the same gain adjustment range, an input impedance of 2 kΩ, and supports 2.5 V plug-in power. These overall specifications provide an overview of the capabilities and characteristics of the XY microphone (XYH-6) and the microphone/line input jack on the device. Liu & Kang's psychoacoustic soundscape parameter approach in response to the cardioid condenser stereo microphone specification has a relationship in the aspect of the need to capture sound hardness [7]. The SPL range required by reviewing Liu & Kang's parameters is in 20 - 80 dB [7]. Compared to the Zoom H8 which has a maximum SPL of up to 136 dB, the Zoom H8 can capture sounds up to peak energy levels SPL which is more than enough for soundscape. The frequency range aspect in Liu & Kang's measurement has a density in frequency to be one that is reviewed with a different view, in PLS the frequency range has energy from 20 Hz - 20,000 Hz. With regard to the sound thickness requirements of the psychoacoustic range there is a need for this parameter to be related to SPL, see Table 2.

Tabel 2. Zoom H8 Field Format Recording Specifications (Zoom Corporation, 2021)

Recording Media	Zoom H-8	
	Cards that support SD/SDHC/SDXC Specifications	
XY mic (XYH-6)	Mic Type	Mic Type
	Sensitivity	–41 dB, 1 kHz at 1 Pa
	Input gain	–∞ to 46.5 dB
	Maximum sound pressure input	136 dB SPL
	MIC/LINE IN stereo mini jack	Input gain: –∞ to 46.5 dB Input impedance: 2 kΩ Plug-in power: 2.5 V supported

The device has highly flexible recording capabilities with support for various formats in FIELD and WAV modes. In WAV mode, the device can record at a sample frequency of 44.1/48/96kHz with a bit depth of 16/24, in both mono and stereo formats, as well as using the commonly used Broadcast Wave File (BWF) format. Users can record up to two tracks simultaneously, with recording source options that include MIC IN, backup recording, as well as tracks 1-4, A, B, and LR to provide detailed control over the recorded audio source. Additionally, in MP3 mode, the device supports various bit rates of 128, 192, and 320 kbps, allowing users to select a compression level that suits their needs and available storage space. In MP3 mode, it is also possible to record two tracks simultaneously, providing the possibility to make backup copies or record from two different audio sources simultaneously. With a wide selection of recording formats and configurations available, this device offers great flexibility for users who

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have diverse needs in the audio recording process. Advances in music technology play a synergistic role as a manifestation of human creativity [28], in the context of this study on the results of exploration of the use of microphones appropriately and accurately. Regarding soundscape and the use of microphones to record sound in the context of psychoacoustics, it was found that soundscape, as a soundscape concept, involves understanding the soundscape in an environment [8].

The concept emerged as a response to noise pollution, as expressed by Schafer who created the concept of soundscape to address noise disturbance while teaching at Simon Fraser University in the 1960s [2]. The development of the concept of soundscape has correlations with the ideas of contemporary music artist John Cage, who posed fundamental questions about what could be considered music [29]. Alongside this, this research illustrates how an approach to soundscape requires an in-depth understanding of psychoacoustic parameters, including audio frequency, sound hardness and time [30]. In the context of soundscape recording, microphone selection is crucial. The findings of this study show that a stereo cardioid condenser microphone, such as the Zoom H8, can be an efficient choice. It has the ability to record within the SPL range corresponding to the psychoacoustic parameters analyzed, covering the frequency range relevant for the soundscape. The Zoom H8 also provides recording flexibility with support for a variety of formats, including WAV with a high sample frequency and MP3 format. WAV with high sample frequency can support the need for recordings with different compression levels, according to user preferences [31]. Thus, this study provides a comprehensive view of the relationship between psychoacoustic parameters in a soundscape and the selection of microphone types for recordings. The findings can provide practical guidance for audio professionals and researchers interested in recording and understanding soundscapes.

4. Conclusion

This research provides a comprehensive view of the relationship between psychoacoustic parameters in soundscapes and the selection of microphone types for recording. The implications include a deeper understanding of our sound environment and provide practical guidance for audio professionals and researchers in recording and understanding soundscapes holistically. Using a literature review approach, this research outlines the relationship between the concept of soundscape, psychoacoustic parameters and microphone selection, opening the door for further development in understanding our sound environment. The microphone selection discussed mainly focuses on a specific model, the Zoom H8. While this model showed good agreement with the psychoacoustic parameters, this study did not include a variety of microphone types from different manufacturers, or other models that may have different characteristics. Therefore, keep in mind that the results of this study may not be fully applicable to all available microphone types. The psychoacoustic parameters analyzed in this study only include audio frequency, sound hardness, and time. There is potential for further research by considering other parameters that might affect the soundscape experience, such as sound texture, dynamics and acoustic uncertainty. The conclusions of this study emphasize the importance of understanding the interrelationship between psychoacoustic parameters in the context of soundscapes and the selection of microphone types for sound recording. Cardioid stereo condenser microphones emerged as an efficient choice that can support the desired soundscape characteristics. Nonetheless, this research provides an initial foundation, and further research with more robust experimental designs and field testing can further enrich our understanding of the complex relationship between soundscapes, psychoacoustics and sound recording devices.

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