

CHAPTER II LITERATURE REVIEW

2.1. Theoretical Review

This section contains literature on the basic concepts of this research, which includes the main theories underlying the research approach, such as the concept of soundscape, perception of the sound environment, and the differences in characteristics between urban and rural areas. This explanation aims to provide a theoretical foundation in understanding how acoustic environments are perceived by individuals based on their spatial and social contexts. In addition, the literature covered also includes methods of evaluating sound perception, including the use of technologies for soundscape measurements and EEG measurements, which form an important part of this research approach.

2.1.1. Term of Soundscape

Soundscape encompasses all sounds within a given environment (Schafer, 1994). A multidisciplinary approach is imperative to comprehend this phenomenon, encompassing musical, acoustic, ecological, and functional dimensions. The concept of soundscape encompasses both natural acoustic environments generated by animal and plant vocalizations and artificial acoustic environments produced by anthropogenic sounds, such as music, speech, and mechanical noise. The concept of soundscape encompasses three primary components: human interaction, the acoustic environment, and perception. Soundscapes have the capacity to illustrate the association between humans and the acoustic milieu that envelops them (Mitchell, Aletta, Oberman, & Kang, 2023).

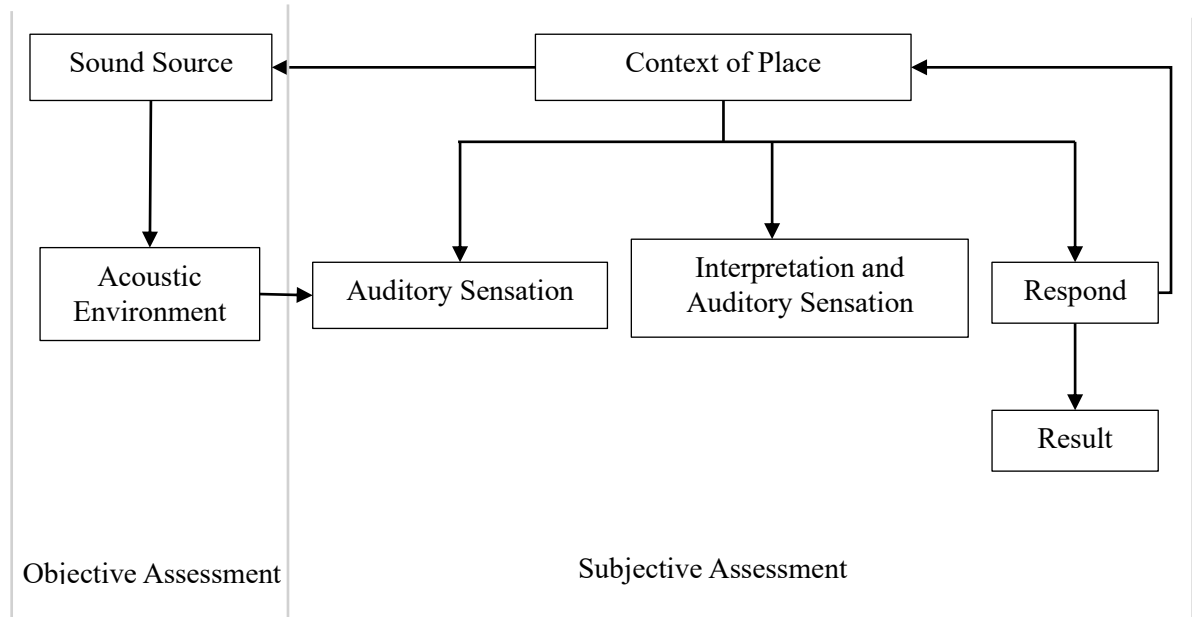


Figure 2. Soundscape Framework adapted from ISO 12913 – 1

The term "soundscape" is defined as a comprehensive representation of the acoustic environment, encompassing both objective and subjective elements as referred in **Figure 2**. Objective understanding can be obtained from the condition of the acoustic environment itself. This understanding is then perceived and understood by humans through auditory sensations that they feel and interpret. These sensations form an understanding of the context of a place or environment.

2.1.2. Acoustic Environment

The acoustic environment of a given place or space comprises sounds originating from all perceivable sources within that space (Kang & Schulte-Fortkamp, 2016). The term "soundscape" was initially popularized by Schafer. Subsequently, it was further developed by several individuals and organizations. The definition of soundscape that has emerged is that of the acoustic environment perceived by an individual or group within their respective context (ISO 12913-1, 2014; Mitchell et al., 2023).

Kang and Schulte elaborate on the idea that acoustic environment is made up of specific sounds that are either present or absent. The utilization of these acoustic phenomena facilitates the identification and classification of sounds into various categories. One such system that has been put forth by Gage categorizes sounds as biophonic, geophonic, or anthropogenic. Biophonic sound sources are defined as acoustic phenomena that originate from biological entities such as birds or insects. Geophonic sound is derived from physical processes that generate acoustic phenomena, including wind, rain, waves, water flow, lightning, earthquakes,

and volcanic activity. In contrast, anthropogenic sound is produced by human activities and human beings.

2.1.3. Urban Soundscape

Kang and Schulte (2016), in their study, describe urban soundscape as a complex acoustic environment. It is defined as a place that has characteristics of combining elements of population density, social, and economic and transformation from natural to built environments. Significantly different from rural areas, urban areas are categorized as non-agricultural places where there is no empty land or a mix of vegetation and bare soil. Urban areas are more dominated by dense development reflecting largely impervious surfaces (Weeks, 2010).

Urban soundscape is included in the category of outdoor acoustic environment along with rural acoustic environment, wilderness acoustic environment, and underwater acoustic environment. Focusing on urban soundscape through research that has been done as shown in **Figure 3**, the classification of the existence of sounds in urban soundscape looks more complex because of the many types and sources produced by anthropogenic sound. Even so, the existence of sounds that are not produced by humans is still real, namely nature sound and domesticated animals. Nature sound itself can consist of biophonic sound and geophonic sound which come from the sound of wind, water, lightning, etc. Anthropogenic sounds have many sources, namely sounds produced by motorized transportation, human movement, electromechanical such as stationary or mobile, voice and instrument, social or communal activities, and other human sounds.

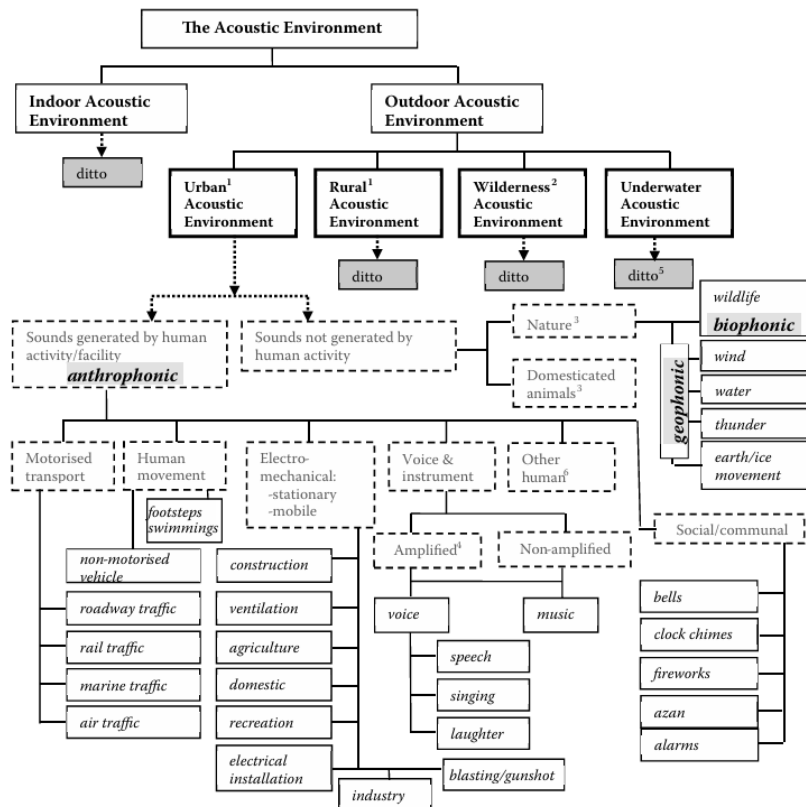


Figure 3. Classification scheme of sound categories in any acoustic environment modified by Kang and Schulte (2016)

2.1.4. Rural Soundscape

Unlike complex urban soundscapes, rural soundscapes can be defined as a restorative and tranquil soundscape that can provide calm from cognitive burden and can reduce stress since artificial sounds are very minimal and are more dominated by natural sounds (Ren, Kang, Zhu, & Wang, 2018). Rural acoustics encompass a balance between calm and tranquility, along with biological sounds (biophony), geographical sounds (geophony), and man-made sounds (anthropony). Study by Maichi Chen (2021) added that sounds originating from agricultural activities, such as birds chirping, cows mooing, and the chatter of plowmen, which reflect the traditional rhythms of rural communities are also included as rural soundscape compositions.

Research by Ren (2018) shows that the presence of natural soundscapes significantly increases calmness scores, thereby substantially increasing evaluations for both positive and negative soundscapes. Furthermore, soundscapes can modulate the influence of certain landscape elements (such as vegetation and water) on overall evaluations, with certain disturbing elements (such as traffic noise) potentially reducing perceived landscape quality.

2.1.5. Perception

According to Robbins and Judge (2018), perception is the process by which individuals organize and interpret sensory impressions to give the environment meaning for them. Each individual has a different stimulus from each other so that what one person receives can be different from the objective reality and perception of others. The way in which a situation is perceived tends to be more important than the situation itself.

Human perception of soundscape is a complex phenomenon that involves various interactions such as cultural, social, psychological and physical factors. People's perception of soundscapes is influenced by their personal experiences, socio-culture, emotions, and psychological and physiological conditions. Several other studies have shown that people tend to prefer some sounds based on their cultural background or references. Qualitative field research shows that human perception of soundscape is influenced by cognitive effects through the soundscape meaning of cultural differences and one's sound preferences (Fiebig, 2023).

2.1.6. Neuroscience

Neuroarchitecture, an emerging interdisciplinary field, explores the intersection of neuroscience and architecture to understand how built environments impact human experience and well-being (Coburn, Vartanian, & Chatterjee, n.d.; Karakas & Yildiz, 2019). This approach utilizes neuroscientific techniques and virtual reality to study cognitive and emotional responses to architectural spaces (Higuera-Trujillo, Llinares, & Macagno, 2021). Neuroarchitecture aims to create environments that enhance physical, intellectual, emotional, and social well-being by considering four pillars: body, brain, emotions, and behavior (Medhat Assem, Mohamed Khodeir, & Fathy, 2023). According to Coburn, the discipline takes cues from neuroaesthetics and aims to become an experimental science that tackles both theoretical and technical issues. In summary, researchers have conducted systematic reviews to explore emerging concepts and methodologies in neuroarchitecture, emphasizing its potential to inform design practices and improve human experiences in built environments (Higuera-Trujillo et al., 2021; Karakas & Yildiz, 2019; Medhat Assem et al., 2023).

2.1.7. Auditory Processing in Brain Part

The temporal lobe is part of the brain that bears the role of hearing (Silva, Sousa, Mestre, Nzwalo, & Nzwalo, 2020). Auditory components such as sound, speech, and language are processed by the brain in this part (Swain, 2025). The auditory cortex, which is located on the superior temporal gyrus of the temporal lobe, is responsible for decoding different frequencies, pitches, and the timing of sounds. This enables humans to distinguish speech, music, and environmental noises (Purves et al., 2001).

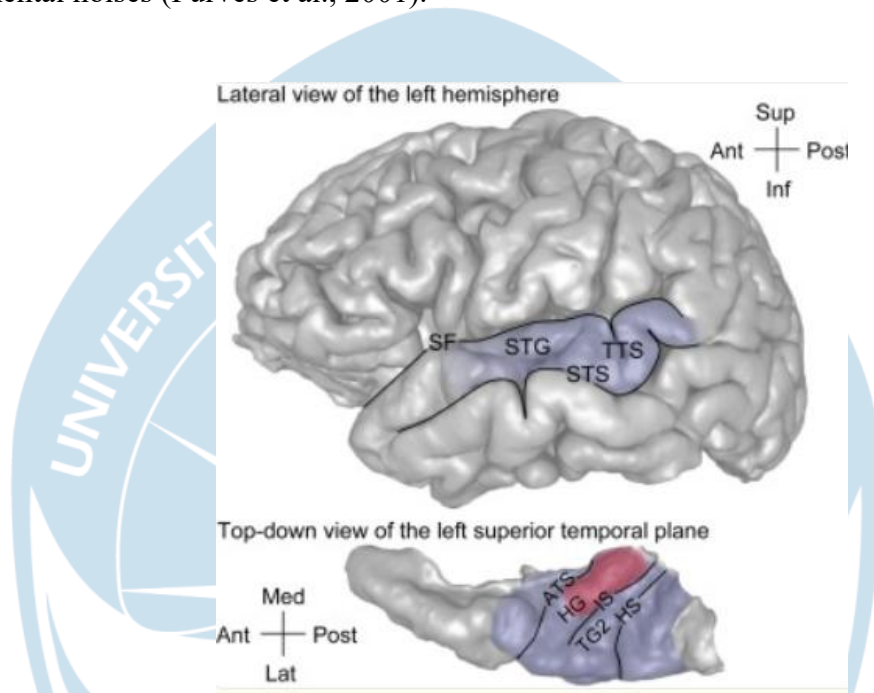


Figure 4. Approximate location of the auditory cortex by Nourski (2017)

2.1.8. Electroencephalography (EEG)

Electroencephalography (EEG) is a neurophysiological technique used to measure and record the electrical activity of the brain (Chaddad, Wu, Kateb, & Bouridane, 2023). It involves placing electrodes on the scalp to detect the spontaneous electrical potential generated by neurons in the brain. EEG signals are noninvasive, making them a safe and widely used method in biomedical research and clinical diagnostics.

Chaddad's study emphasizes that EEG works by detecting the electrical potential produced by neuronal activities on the surface of the brain. When neurons fire, they generate tiny electrical signals, which can be recorded using electrodes placed on the scalp. These electrodes capture the biological potential, reflecting the aggregated activity of large populations of neurons in the cortex.

The signals captured are typically in the form of oscillations across different frequency bands—such as delta, theta, alpha, beta, and gamma—which correspond to various states of

alertness and cognitive activity. The raw EEG signals are often contaminated with noise (from muscle activity, eye movements, etc.) and require preprocessing, including denoising techniques, to extract meaningful information.

EEG records brain activity in the form of continuous electrical waves. These waves have different frequencies and amplitudes, depending on the functional state of the brain. In general, there are several main types of brain waves:

1. Delta waves: Low frequency (0.5-4 Hz), associated with deep sleep and coma.
2. Theta waves: Medium frequency (4-8 Hz), associated with relaxation, drowsiness, and creativity.
3. Alpha waves: Medium frequency (8-13 Hz), associated with wakefulness and resting with eyes closed.
4. Beta waves: High frequency (13-30 Hz), associated with cognitive activity, alertness, and concentration.
5. Gamma waves: Very high frequency (above 30 Hz), associated with high-level information processing and integration of brain functions.

2.2. Methodology

This section will contain the literature that supports the selection of the research approach method to be used in this study.

2.2.1. Soundscape Questionnaire

ISO 12913 – 2 outlines three methods for measuring soundscape:

1. Method A

Method A is a quantitative data collection protocol that allows for the expression of all responses as numerical data. The method under consideration involves the administration of a questionnaire comprising three sections: sound source identification, perceived affective quality, and overall quality. Participants or respondents are invited to rate each question on a 5-point Likert scale. This method is effective for studies that classify spaces or examine general trends among large populations.

2. Method B

Method B is a quantitative and qualitative data collection protocol that combines numerical and character data. Method B employs a questionnaire that incorporates open-ended inquiries to assess soundscapes, identify sound sources, and assign rankings. It also allows for the submission of supplementary remarks. Participants

are instructed to employ a 5-point Likert scale to rate questions, while other sections of the survey permit open-ended responses. This method is useful for generating predictive models of perception with statistical validation.

3. Method C

Method C is a qualitative data collection protocol that utilizes oral responses. This method entails the conduction of narrative interviews, which consider the residential context. Participants are encouraged to offer complimentary responses to inquiries regarding sound sources and their comprehension of the acoustic milieu. This method is recommended for studies that require in-depth analysis of space or target a small population.

2.2.2. Emotiv EPOC X

The Emotiv EPOC X is a high-resolution, portable electroencephalogram (EEG) headset with 14 channels. It is designed for brain-computer interface (BCI) research, cognitive neuroscience, and real-world neurotechnology applications. The product under consideration was developed by Emotiv and is part of the company's EPOC series. It is frequently utilized in academic, clinical, and commercial research due to its balance of usability, mobility, and data quality.

The EPOC X headset is designed to record brain activity from the frontal and prefrontal regions, as well as the temporal, parietal, and occipital lobes. The sensor placement adheres to the international 10-20 system, as illustrated in the following figure: **Error! Reference source not found.**(b). The device is equipped with two electrode arms, each comprising nine positions, including seven active sensors and two reference points. The M1 and M2 positions are outfitted with comfort pads, as they function as alternative reference sites for P3 and P4.

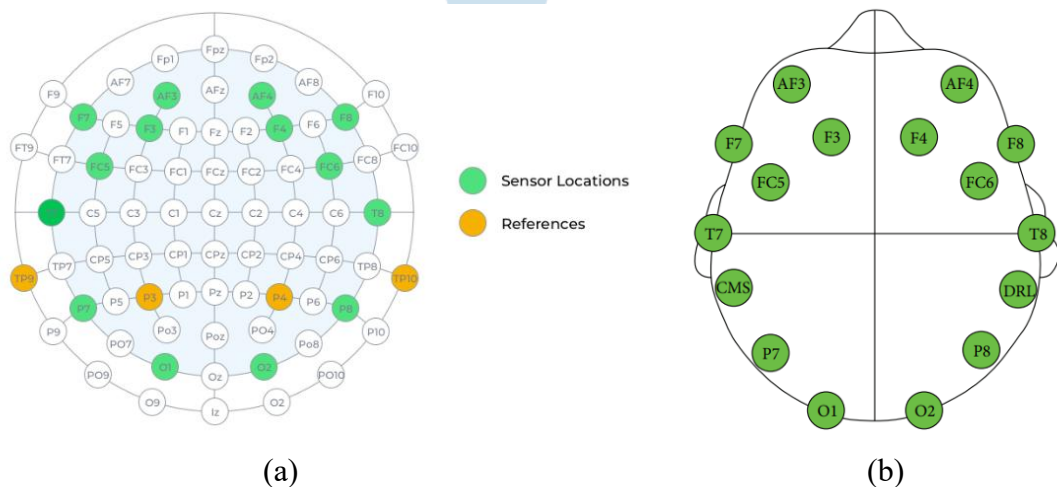


Figure 5. (a) The electrodes' layout on the scalp, (b) International 10-20 system electrodes position

The electrodes mentioned (AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F8, F4, AF4) refer to the electrode locations on the Emotiv EPOC electroencephalogram (EEG) system. Each code identifies the position of the electrodes on the user's head shown in **Table 1**.

Table 1. Electrode classification

ELECTRODE	AREA
AF3	Electrode positioned on the area above the left eye (left pre-frontal)
F7	Electrode positioned on the front area of the left side of the head
F3	Electrode positioned on the center front area left side of the head
FC5	Electrode positioned on the center area of the left side of the head
T7	Electrode positioned on the center back area of the left side of the head
P7	Electrode positioned on the area behind the left side of the head
O1	Electrode positioned on the area above and slightly behind the left eye (left occipital)
O2	Electrode positioned on the area above and slightly behind the right eye (right occipital)
P8	Electrode positioned on the area behind the right side of the head
T8	Electrode positioned on the center back area of the right side of the head
FC6	Electrode positioned on the center area of the right side of the head
F8	Electrode positioned on the front area of the right side of the head
F4	Electrode positioned on the center front area of the right side of the head
AF4	Electrode positioned on the area above the right eye (right pre-frontal)

The position of these electrodes covers various areas around the head to record brain activity from different parts of the brain. The data obtained from these electrodes can then be interpreted for brain activity analysis in the context of neurofeedback and other cognitive studies. In the Emotiv EPOC system, there are no less than 14 main electrode channels used to record brain activity. Apart from these electrodes, there is also what is called Performance Metrics, an additional feature that enriches the functionality of this device. The Performance Metrics consists of six metrics that represent different types of emotions that can be detected through the user's brain activity.

2.3. Related Studies

Many studies on soundscape and EEG have been conducted and intersected. However, there has not been much specific research on urban and rural soundscapes with EEG studies, especially by combining EEG-based measurement methods with soundscape assessment.

Table 2. Related studies

Authors, year	Title	Summary	Differences
(Jeon et al., 2018)	Cross-National Comparison in Assessment of Urban Park Soundscapes In France, Korea, And Sweden! This Study Explores How Socio-Cultural Context, Including Language, Can Impact Soundscape Assessments In Urban Parks	The study compared urban park soundscape assessments in France, Korea, and Sweden through laboratory experiments. Participants rated the dominance of sound sources and affective quality. Results showed differences in perceived affective quality, particularly Eventfulness, across cultures, with varied classifications of recording locations. This highlights the importance of standardizing methods for cross-national soundscape comparisons. Limitations included sample size, stimuli selection, and experimental condition variations. The study emphasized socio-cultural factors in urban soundscape perceptions.	This study compares specific urban park soundscapes across different countries (France, Korea, Sweden) using laboratory experiments and standardized assessments

(Papadakis et al., 2023)	City, town, village: Potential differences in residents soundscape perception using ISO/TS 12913-2:2018	The study used ISO/TS 12913-2:2018 to investigate soundscape perception differences among city, town, and village residents. Attributes like monotonous, chaotic, and vibrant sounds showed significant variation. Sound stimuli were categorized into technological, natural, and human sounds, revealing location-based perception differences. The study emphasized the need to consider residents' location in cross-cultural soundscape research for accurate conclusions.	Focuses on comparing soundscape perceptions among residents of cities, towns, and villages
(Tarlao, Steele, & Guastavino, 2019)	Investigating factors influencing soundscape evaluations across multiple urban spaces in Montreal	The study in Montreal analyzed soundscape evaluations across five urban sites: Public Square, Pocket Park, Green Park, Pedestrian Zone, and a Restaurant. Factors like social interaction, noise sensitivity, and site characteristics were examined using statistical methods including MANCOVA and PCA. Results underscored social interaction and site type as pivotal in shaping perceptions, often described in terms of pleasantness.	Analyzes soundscape evaluations across specific urban sites in Montreal, focusing on factors like social interaction, noise sensitivity, and site characteristics.

(Ali, Mahmoud, & Aboubakr, 2021)	Gabr, Assessing and Characterizing the Perception of Soundscape in the Urban Park: A Case Study of Zayed Park, Egypt	This study examines the significance of soundscape in Zayed Park, Egypt, finding an inverse relationship between traffic noise and pleasantness, and a positive correlation between natural sounds and pleasantness. The study recommends audio-visual simulations for soundscape management and planning.	This study aims to investigate soundscape patterns in urban parks. Specifically, the study seeks to understand how park visitors in Egypt perceive soundscape features and patterns.
(Chia Jen Yu & Kang, 2014)	Soundscape in the sustainable living environment: A cross-cultural comparison between the UK and Taiwan	The study compared acoustic environments in Sheffield, UK, and Taipei, Taiwan, focusing on noise annoyance, sound preferences, and comfort. Cultural factors significantly influenced perceptions, with 'quiet' crucial for living environment choice in both regions. Taipei residents rated their acoustic environment less comfortable than Sheffield's. Preferences favored 'quiet,' bird songs, and water sounds, with traffic sounds least preferred. Cultural differences, like views on church bells, shaped these preferences, emphasizing cultural considerations in sustainable soundscapes.	Study compares acoustic environments and cultural influences on sound preferences between Sheffield, UK, and Taipei, Taiwan

2.4. Research Gaps

Extant research on soundscapes has focused predominantly on urban environments. Despite growing interest in soundscapes and their impact on human well-being, existing studies predominantly focus on the characteristics and management of either urban noise pollution or rural tranquility in isolation. While these studies provide valuable insights, they fail to address the critical interplay between urban and rural soundscapes—particularly how individuals from these contrasting environments perceive each other's auditory experiences. This gap becomes more significant in the context of urbanization, which often creates a disconnect between urban and rural communities, fostering stereotypes or misunderstandings about the other's environment. Moreover, although advanced technologies like EEG have been utilized in soundscape research, their combined application to study **cross-perceptions** remains underexplored. This presents an opportunity to uncover unique physiological and subjective insights into how individuals engage with unfamiliar soundscapes, ultimately contributing to a more comprehensive understanding of the human-soundscape relationship.