Effect of soundscape on emotional response in an urban acoustical environment

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Abstract

The emotional response in soundscapes has long been the centre of the soundscape field. Despite the efforts of researcher and practitioners, the results on emotional response remain fragmented and inconsistent. This thesis aims to systematically explore the emotional responses in soundscape. By adopting theory from emotional study, this thesis aims to view the subjective assessment of the acoustical environment through the lens of emotional processes.

The thesis started with a case study (Chapter 4) to identify and explore all acoustical and environmental stimuli that have the potential to influence emotional responses. The case study was conducted on-site and provided a preliminary examination of the identified stimuli. The identified stimuli included weather conditions (daylight difference and thermal conditions) and sound types (street music, shop music, traffic sound, machinery sound and fountain sounds). Six mood states were studied: anger; confusion; depression; fatigue; tension; and vigour. The results showed that lighting and thermal condition do not impact people's mood states; music from street performances reduces negative mood states; music from shops increases negative mood states, especially tension; and nature sounds have a non-significant influence on mood states, as do monotonous sounds such as traffic and machinery.

The second and third studies (Chapters 5 and 6, respectively) further examined the stimuli that were found to have a significant influence on emotional responses in the initial case study in the laboratory setting. With the controlled environment of the laboratory, the results of the two studies eliminated bias from the result of the initial case study. The study in Chapter 5 focused on the effect of sound types on emotional responses and the study in Chapter 6 focused on the environmental context and aimed to identify their effect on emotional responses when perceiving acoustical environments.

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Table of Contents

List of Acronyms

A	Alpine meadow context
ANOVA	Analysis of Variance
C	Monk chanting context
COR	Conservation of resources
dB	Decibel (unweighted)
dBA	Decibel (A-weighted)
F	Fountain sound
FA	Fountain sound and Alpine meadow context
FC	Fountain sound and Monk chanting context
FTc	Fountain sound and Temple courtyard context
ISO	International Organization for Standards
M	Street music
MA	Street music and Alpine meadow context
MANOVA	Multivariate Analysis of Variance
MC	Street music and Monk chanting context
MTc	Street music and Temple courtyard context
ns	Not significant
PCM	Principle Component Model
POMS	Profile of Mood States (questionnaire)
SPL	Sound Pressure Level
T	Traffic sound
TA	Traffic sound and Alpine meadow context
TC	Traffic sound and Monk chanting context
Tc	Temple courtyard context
TMD	Total Mood Disturbance
TTc	Traffic sound and Temple courtyard context

List of Figures

List of Tables

Chapter 1 Introduction

1.1 Background

A soundscape is defined by the International Organization for Standardization (ISO, 2014) as an "acoustic environment as perceived or experienced and/or understood by a person or people, in context". The key of the soundscape study is that of subjective perceptions. This is different from acoustic research, where the objective properties of the sound are the focus; instead, soundscape focuses on how people perceive sounds. If the subjective assessment of the sound is the focus, then the subjective feeling is also involved. This is also explained in ISO/FDIS 12913-1, where the emotional states of a person can affect his/her responses towards an acoustic environment (ISO, 2014).

Soundscape as defined by the ISO (2014) consists of seven main concepts: context; sound sources; acoustic environment; auditory sensation; interpretation of auditory sensation; responses; and outcomes. Mood/emotions are directly involved in three of the concepts in soundscape, namely context, response and acoustic environment. Mood/emotion also indirectly affects the outcomes of the perceived soundscapes. Within the definition of the soundscapes, mood/emotion are defined as part of the context and, as such, has an effect on the response of the acoustic environment; in turn, it can affect the outcomes of the perceived soundscape. In the definition provided by the ISO (2014), there is no description of the relationship between mood/emotions and auditory sensation or interpretation of the auditory sensation. In fact, these two concepts have an important role in the formation of the mood/emotion (see Section 2.1.4). Regardless, extensive studies have been conducted in an attempt to understand the relationship between soundscapes and mood/emotions.

One of the most important studies in the relationship between soundscape and emotional responses was the development of the Principle Component Model (PCM). The model uses a mixture of the three emotional dimensions (pleasantness, eventfulness and familiarity) to represent the emotional nature included in all sounds. This model enables the study of emotions in soundscapes (Axelsson, Nilsson & Berglund, 2010). The PCM was developed from the core affect model of the emotion (Russell, 2003) and both models share the same dimension and orthogonal model structure. However, the two models also share the same disadvantages. The core affect model cannot sufficiently distinguish between some of the mood/emotional categories. This insufficiency has also been translated into the PCM despite efforts made at improving the model by uncover and additional dimension – familiarity. Nevertheless, the PCM has been widely utilised in soundscape research and its development has provided the foundation for mood/emotional studies on soundscape.

A number of soundscape studies have attempted to explore the effect of soundscape on emotions/moods by assessing these factors through PCM. The majority of these studies focused on the subjective quality of acoustic environments (such as the annoyance or pleasantness of sounds) that have been studied. Although the three emotional dimensions of the PCM was sufficient for the aims of these studies, there was no systematic exploration of the fundamental relation between the acoustic environment and emotional responses, for example, how and why a certain emotional response was elicited by an acoustic stimulus. Further, no effort was made to study how soundscape will influence the distinctive emotions beyond pleasantness, eventfulness and familiarity. This is largely due to a simplified understanding of the emotional development process. Indeed, the emotional responses in the soundscape are mostly treated as outcomes rather than complete processes. This simplification has hindered an understanding of the relation between the perceiving process of the acoustic environment and the emotional process.

The three-dimensional model of PCM only explains emotions as a combination of only the three dimensions. A distinctive emotion such as anger cannot be defined by a specific combination of the three dimensions. On the one hand, the emotion responses defined by PCM is rather a prototype of emotions, rather than distinct emotions. An understanding of the fundamental mechanism of the emotional process, on the other hand, enables the examination of distinctive emotions. The mechanism (see Section 2.2) explains how a distinctive emotion is formed as a result of a process, rather than how it has been perceived as an outcomes. If the understanding of the emotional process is implemented in research studies, this can explain why a person feels a distinctive emotion, what factors have caused it, and how exactly the factors caused it. This information is invaluable to researchers and designers alike, as it provides control over the source of the emotional responses rather than the factor(s) that contain the source. A fundamental understanding of the emotional process, then, provides more possibilities when one intends to enhance or reduce certain emotional experience(s) from an environment. Returning to the PCM, the results only allow for methods such as the removal, adding or covering (e.g. sound masking) of a certain stimulus from the environment. An understanding of the emotional process, however, means that it is possible to modify an existing stimulus to achieve a different emotional experience without the removal or introduction of stimuli into a given environment.

1.2 Research aims, questions and objectives

1.2.1 Research questions

This thesis seeks to explore the fundamental relationship between emotion and soundscape. By examining the distinctive emotional responses to soundscape stimuli, this thesis aims to provide a systematic knowledge of the relationship between soundscape and emotions. The emotional responses were explored in categories, such as in distinct emotions like anger or tension. This implementation of distinctive emotion types and emotional categories was adopted with the aim to find more information between soundscape and emotions, where the PCM fails to do. Soundscape stimuli that were explored include sound types, sound level, environmental context (visual and audio), weather condition (temperature and daylight) and non-environmental factor (gender). The urban setting is selected as the primary focus for the thesis study, as the rich sound types and environmental diversity of the urban setting would provide variety in stimuli for the thesis study.

The research questions of the thesis are as follow:

1. How does the soundscape of urban public spaces affect mood or emotions?
    a. Does urban public soundscape affect moods or emotions?
    b. Does urban public soundscape improve or harm (increase or decrease positive or negative emotional responses) the moods or emotions felt in the environment?
2. How do sound types affect mood and emotions in urban contexts?
    a. Do different types of sound in an urban public environment affect moods or emotions?
    b. Do specific sound types improve or harm the moods or emotions felt in urban public spaces?
3. How does environmental context affect mood and emotions?
    a. When listening to urban sounds, do different contexts in urban public spaces affect moods or emotions?
    b. When listening to urban sounds, do specific contexts (other than urban public space) improve or harm the moods or emotions felt?

1.2.2 Research objectives

Objective 1

The first objective (responding to the first research question) of the study is to set up the foundation of this thesis through using a case study to investigate how people react in a real urban setting with minimum interference from researchers. People’s reaction to the environmental factors such as weather condition and sounds types were observed and investigated in this study. The information extracted from this case study will be used as the basis for the two following studies (the two following studies refer to Chapters 5 and 6, respectively). The information that has been determined includes:

- Identifying sound types that present within an urban public context;
- Identifying environmental conditions that have the potential to affect mood/emotional response;
- Identifying sound types that elicit a significant mood/emotional response; and
- A preliminary data analysis of any identified factors (sound types and environmental conditions) in relation to mood/emotions.

Although statistical analysis will be carried out to identify any potential relationship existing between each factor and the mood/emotional categories, biases in the results are expected, as the on-site condition cannot be completely controlled.

Objective 2

The second objective (responding to the second research question) is to examine the sound types identified to have a significant effect on mood/emotions in the previous case study (see (objective 1). This object will be accomplished by laboratory study and utilising sound recordings and audio replays based on the previous case study (see objective 1). The experiment will first try to recreate the mood/emotional outcomes from the case study to determine the difference between the on-site (natural) condition and the laboratory (controlled) condition. Subsequently, statistical analysis will be carried out across different sound recordings to try to identify the possible effect of individual sound types or combinations of sounds towards each sound category. To answer research question 2, the following sub research questions were asked and explored:

- How does sound type affect mood/emotions?
- How does the sound level affect mood/emotions?
- How does social demographical differences affect mood/emotions?
- Are there any other contexts beyond sound that affect mood/emotions?

Objective 3

After exploring the aspect of sound and listeners, the third objective (responding to the third research question) attempts to examine how different environmental contexts affect mood/motional outcomes when perceiving an acoustic environment. Environmental context is a crucial part of the interpretation of a subjective soundscape experience, and context can have a significant effect on the perceived soundscape quality. It is expected that environmental contexts will have the same effect on the interpretation of mood/emotions as sound types. The third study will attempt to answer research question 3 by asking and answering following sub questions:

- If and how do contexts affect mood/emotional states when listening to sounds in general?
- How does context affect mood/emotional states when listening to different types of sound?
- How do audio and visual stimuli in contexts affect emotional responses when perceiving an acoustic environment?
- How does gender differences affect emotional responses under different contexts?

1.3 Thesis structure

This thesis consists of one case-study, two laboratory studies and a chapter that synthesises the results of all three studies by discussing their combined achievement, limitations and potential implications of the studies. The three studies (corresponding to Chapters 4, 5 and 6, respectively) can be viewed as a collective study of ‘effect of soundscapes with different sound types and environmental context on distinctive emotional responses’. The first study (chapter 4) is in response to research question 1, to invstigate general effect of urban soundscape on moods or emotions. It also as a preliminary case study conducted on-site that aims to provide a real-world basis (and the results from the study) for comparison with the two subsequent studies (objectives 2 and 3). The second and third study (Chapter 5 and 6 respectively) share similarities in terms of research method and sub-research questions; the difference is that each of the two studies is concerned with one major factor in the soundscape. One of the studies (chapter 5) is focused on effect of sound (types and sound levels) on emotional responses the other study (chapter 6) is focused on the effect of environmental context (visual and audio) on emotional responses. As all three studies require human participants, the impact of the social demographical difference on mood/emotions was explored across the three studies. Chapter 7 synthesises and complements the three original studies, and consists of a discussion of the combined findings, contributing to mood/emotional studies in soundscapes and implementations across all three studies. A detailed synopsis of the individual chapters will now be set out.

Chapter 1-‘Introduction’ introduces the research background (context), including a glance at the existing literature in soundscape studies that involves moods and/or emotions, prior to briefly discussing the gaps and inefficiency in the literature. This chapter demonstrated the potential effect of this thesis on mood and emotions in the soundscape field. The aims, objectives and structure of the current research thesis were also set out here, along with the research questions.

The first part of Chapter 2-‘Literature review’ provides a detailed review of the existing literature that has in some ways provided an understanding of the relation between mood/emotions and soundscapes. This review provides an explanation of structures and inefficiencies in emotional related study within field of soundscape. Methods of exploring the emotional aspect (including machine learning and mapping) were also reviewed. Subsequently, the literature review also covers the emotional theories beyond soundscape studies, through adopting a holistic understanding of the emotional process. This chapter concludes with how an integration of the appraisal theory of emotion (which explains the emotion forming process) can be beneficial for soundscape research.

Chapter 3-'Methods and methodology' clarifies the standard procedure and method used in soundscape researches, also general methods implemented in the three studies were explained. This including audio recordings, audio replay, questionnaires and data analysis methods. This chapter also explains how implicit reactions were implemented in the thesis researches.

Chapter 4-'Effect of soundscape on mood states in urban pedestrian space: a Sheffield case study' explored how the environmental aspects of urban public space affect people's emotional responses. This study has tried to distinguish the explicit conscious emotional process from the implicit unconscious emotional process in an attempt to observe a natural emotional reaction. Data were collected through the Profile of Mood States (POMS) and analysed statistically. Six emotional categories (anger, confusion, depression, fatigue, tension, and vigour) were examined against the observed acoustical and environmental stimuli (including weather condition, sound types, and visual contexts). Statistical analysis was conducted to identify whether the observed stimuli had a significant effect on the six categories of emotional responses. The stimuli observed with significant or potential significant effects were then further examined in the following two laboratory studies (chapter 5 and 6).

Chapter 5-' Effect of sound types of an urban environment on mood states' examines the relationship between three urban sound types (street music, traffic sound, and fountain sound) and six emotional categories (anger, confusion, depression, fatigue, tension, and vigour) in a controlled laboratory setting. Similarly, this study also distinguished the explicit conscious emotional process from the implicit unconscious emotional process for natural emotional responses. The three sound types were combined in four sound clips to stimulate the sound conditions of an acoustic environment. The reverberation time was also modified to match the targeted outdoor urban contexts. The POMS questionnaire was used to observe the emotional reaction of the three emotional categories after listening to the four sound clips. The data was then analysed statistically and interpreted through the lens of the appraisal theory of emotion. This was done in order to provide a fundamental understanding between the emotional responses and sound types.

Chapter 6-'Effect of the environmental context pertaining to different sound source on the mood states' investigated the effect of non-urban contexts on emotional responses when appraising urban sounds. Three sound types (street music, traffic sound, fountain sound) and three environmental contexts (courtyard and monk chanting scenarios specific to a Buddhist temple, Alpine meadows) were combined to create 12 groups of visual and audio stimuli. Multiple audio playbacks were performed. The experiment was designed with the implicit and explicit emotional responses in mind in order to observe the natural reaction of participants. The emotional responses to each stimuli group were recoded through the POMS questionnaire and the data was analysed statistically. Interpretation of the result is based on an understanding of the appraisal process. The effect of the non-urban contexts was analysed not only based on the differences between each context but also on the environmental factors that composed of each contexts. This study has provided a systematic understanding between environment and emotional responses that are beyond acoustical stimuli in soundscape studies.

Chapter 7-‘Discussion’ presents the conclusions and results from the three thesis studies (Chapters 4,5 and 6), following analysis and comparison. Discussions were made according to the three research questions. The discussions were also made from the perspective of each of the six emotional categories that have been studied. Moreover, the conclusions and discussions integrated the findings of the three thesis studies and provided a holistic understanding of the fundamental system of emotional reactions to acoustic environments.

Chapter 8-‘Conclusion and future works’ concluded the findings of the thesis regarding the three research questions and sub-questions. The effects of sound types, contexts and gender difference on emotional responses were concluded. The intercorrelation among the findings of all three studies were concluded. This chapter also sets out the direction for future studies to facilitate the further development of emotional studies in soundscapes.

Chapter 2 Literature review

To better understand the interactions between soundscapes and emotional responses, this chapter reviewed current soundscape literature that involves emotional consideration in the research process or results. Established emotional dimensions in soundscape were also discussed. Following the review of soundscape literature, this chapter reviewed the formation process as understood within the field of psychology. A discussion of an emotional forming theory (the appraisal theory) and its potential integration with soundscape research was also made.

Figure 2.1 shows the structure of this chapter and explains the current state of emotional study in soundscapes. The figure also indicates what is lacking, following the psychological theory that explains the emotional process – appraisal theory, and why soundscape should adopt the theory to reinforce its shortcoming.

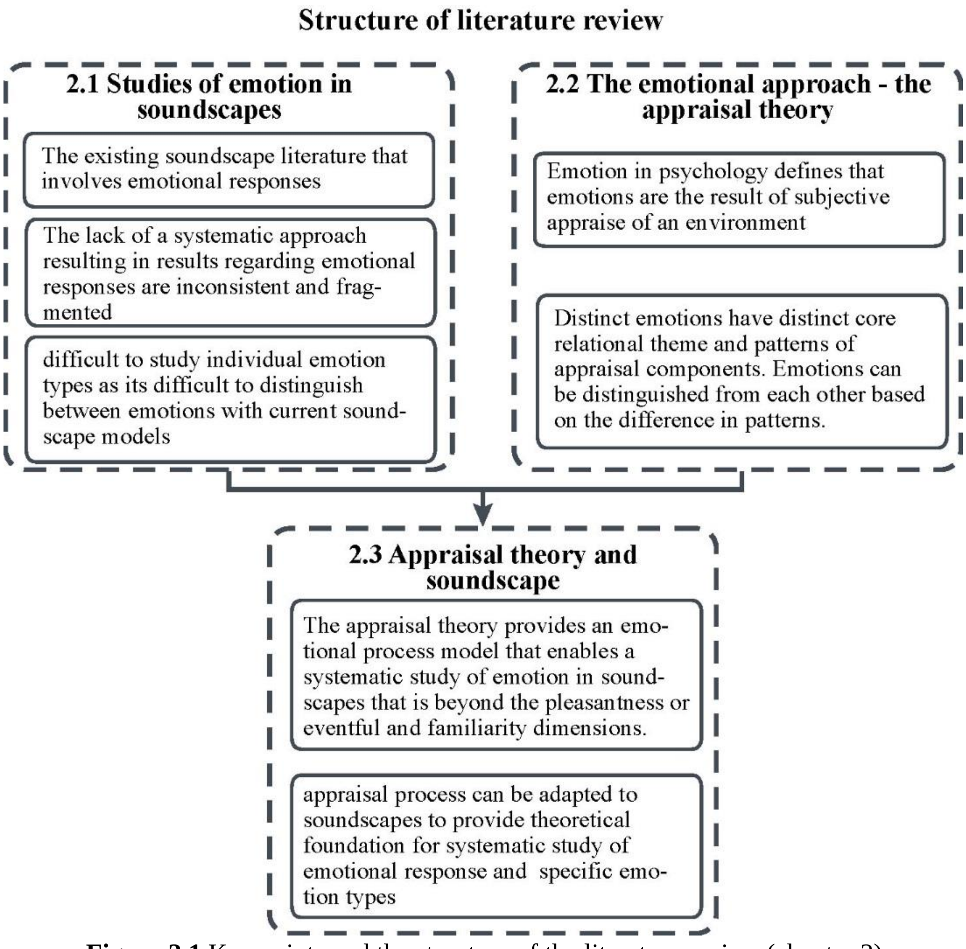

Figure 2.1 Key points and the structure of the literature review (chapter 2)

2.1 Studies of emotions in soundscapes

Before looking into the current soundscape research, the author would like to clarify some vocabulary uses in the following section (section 2.1) to avoid confusion. The use of the words ‘emotion’ and ‘emotional’ in this chapter are general terms for all types of emotions referring to both acute emotion (short-term) and mood (long-term). Unless specified, the words do not refer to either one specifically.

2.1.1 The concept of emotion

Unlike soundscapes, emotion has no single definition. As a scientific term, emotion involves both physiological aspects such as nervous systems (Ekman & Davidson, 1994) and psychological aspects such as appraisal (Roseman & Smith, 2001). In a survey study regarding the definition of emotions, Izard (2010) interviewed 35 researchers across several fields of research including: behavioural and cognitive neuroscience, computational cognitive science, and clinical cognitive, developmental, and social psychological science. Through the interview results, Izard summarised six structural aspects including: 1) processes, 2) response systems, 3) feelings or feeling state, 4) expressive behaviour, signal system, 5) antecedent cognitive appraisal, 6) and cognitive interpretation of a feeling state; and nine relatively functional aspects of emotions including: 1) recruits response systems, 2) motivate cognition and action, 3) organises, orders and coordinates responses, 4) monitors or assesses the significance of events, 5) provides information or meaning, 6) relational, 7) social, 8) controls responses, and 9) motivates behaviour characterised primarily as approach or withdrawal. Although the survey itself did not provide a complete summarisation of all potential definitions included in the emotions, it did indicate the complexity involved in the word emotion within research contexts.

In soundscape, it is generally accepted that emotion is a combination of pleasantness, eventfulness and familiarity (Axelsson, Nilsson & Berglund, 2010), the three dimensions of the PCM. The three dimensions of the PCM in a structural sense are more akin to the ‘feeling or feeling state’ and ‘cognitive interpretation of feeling state’ in Izard’s (2010) study. However, the three dimensions cannot accurately represent individual emotions nor do they explain the process of how emotion is formed (see Section 2.2). This notion of complexity in individual emotions was also recorded in Izard’s survey, where he recorded a statement explaining that different emotions have different structure functions.

2.1.2 The Principal Component Model

The PCM is a 3-dimensional model developed through principal component analysis to evaluate subjective soundscape perceptions. All three dimensions are bipolar dimensions and explain 50% (pleasantness), 18% (eventfulness), and 6% (familiarity) of the soundscape perception, respectively (Axelsson, Nilsson & Berglund, 2010). There were also eight other components discovered alongside the three major ones which explains the other 26% of the variance. However, due to their small percentage in the interpretation of variance (1% to 3% each), they cannot be interpreted meaningfully, hence excluded. The pleasantness dimension is correlated with the emotional valence, which determines the positivity or negativity of a given emotion. The intensity of the mood/emotion is indicated by the eventfulness dimension, and this dimension is correlated with emotional arousal. The third dimension, familiarity, lacks direct association with emotion; instead it is an attribute of perceived sound in relation to listener, which can affect the interpretation of mood/emotion outcomes as well as soundscape quality. The PCM is widely used in soundscape studies to assess the quality of an acoustic environment.

The model's development was heavily influenced by the Core Affect Model, a 2-dimensional model that attempts to categorise mood/emotions through the attribute of pleasure-displeasure and activation-deactivation (see Figure 2.3) (Russell, 2003). The similarity of the two models can be observed in the consistency of the dimensions, where pleasure is similar to the pleasantness of sound(s), and activation is similar to the eventfulness of sound(s). The core affect model is able to explain an emotional episode through a combination of the two affective qualities, pleasure and activation. Hence, the similarity of the two models provides PCM with the ability to evaluate mood/emotional aspect within the subjective soundscape perceptions, thus proving the effectiveness of the PCM in assessing general soundscape qualities, PCM's ability in determine affective quality was also mentioned in (International Organization for Standardization [ISO], 2019). However, the similarity in the two dimensions also indicates the insufficiency of the core affect model in explaining categorised emotions (Russell, 2003). In other words, in attempting to explain categorised moods/emotions, the PCM cannot sufficiently separate the similarities between some of the emotions (e.g. fear and anger). This insufficiency may potentially derive from the methodology underlying the PCM and core effect model. The PCM has tried to capture the complex outcomes of emotional responses that may contain multiple numbers of distinctive emotions into a relatively simplified model (which contains three emotional dimensions). The PCM itself may be sufficient for providing a general summarisation of emotional responses in a given acoustic environment (in terms of whether the emotional outcomes are good or bad and their intensity), but the model does not account for the function of the space (occupied by the sounds) nor the intension of its users. The interaction between the physical environment and the person occupying it plays an important role in the forming and changing of emotional responses (Lazarus, 1991) (see future discussion in the person-environment relationship in section

2.2.1.1). Hence, when considering distinctive emotional categories, it is necessary to identify and develop their dimensions or factors through means such as factor analysis.

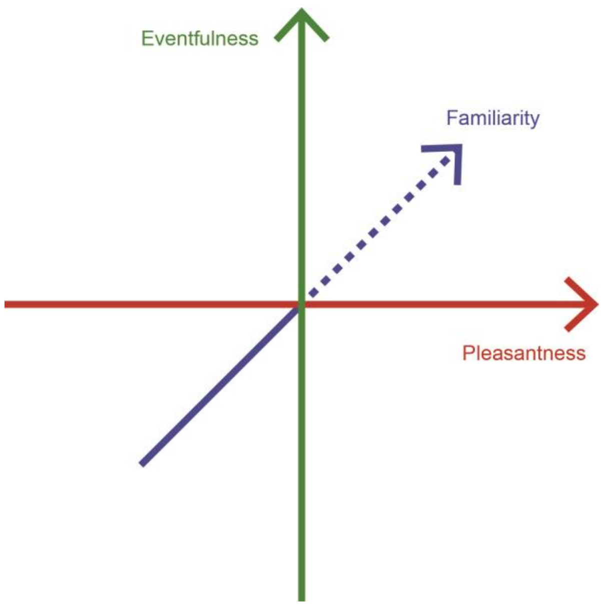

Figure 2.2 demonstration of the three perpendicular dimensions of the principal component model (often only two of the three dimensions are selected and drawn depending on the focus of a study)

Figure 2.3. Core Affect (Russell, 2003): shows the two perpendicular dimensions (pleasure and deactivation) and eight combinations of prototypical emotions

2.1.3 Development of more emotional dimensions

Although less used, there have been a few attempts to develop emotional dimensions beyond the PCM. In a series of studies regarding hospital ward sounds, Mackrill and colleagues discovered and implemented ‘relaxation’ and ‘interest and understanding’ as perceptual dimensions. The ‘relaxation’ dimension measures the emotions relax and stress and the ‘interest and understanding’ dimension measures how much a sound intrigues a person (Mackrill, Cain & Jennings, 2013; Mackrill, Jennings & Cain, 2014; Mackrill, Cain, Jennings & England, 2013). Although these two dimensions are seemingly different from the dimensions contained in the PCM (pleasantness and eventfulness), they are still within the scope of the PCM but only more geared towards a specific environment (hospital wards). The ‘relaxation’ dimension is a combination of ‘pleasant’ and ‘uneventful’ whereas the ‘interest and understanding’ dimension is a combination of ‘pleasant’ and ‘eventful’ mixed with ‘unfamiliarity’(Figure 2.3). Two other dimensions ‘calmness’ and ‘vibrancy’ were developed for soundscape, with the aim to capture how the listener feels when perceiving urban soundscapes, in-order to better guide urban planners (Cain, Jennings & Poxon, 2013). Again, despite differences in aims, the two-dimension can still be explained through combinations of pleasantness and eventfulness (Figure 2.3). The similarity in both sets of dimensions with PCM is likely due to the audio stimuli used for the studies. What is of interest, however, is that although the two sets of dimensions share the same emotional framework with PCM, the axis of the two-dimensional model shifted from ‘pleasant-unpleasant’ and ‘eventful-uneventful’ to ‘pleasant and eventful’-‘unpleasant and uneventful’ and ‘pleasant and uneventful’-‘unpleasant and eventful (Figure 2.3). In addition to attributing this shift to the audio stimuli used in these studies, the other factor involved was the environment that the studies focused on, in this case hospital wards and urban environment. Therefore it is reasonable to assume that different environments and their soundscapes would be associated with a different set of mood/emotions, and that fully explaining these moods/emotions may even require vastly different emotional dimensions.

2.1.4 Mood and emotions in different sound type

Although mood/emotional related soundscape studies have rarely been carried out categorically in terms of mood and emotions, the sounds themselves have always been studied separately in terms of type, context and function. Among these studies, there are varieties of mood/emotionally related findings. As such, this section summarises these findings and aims to identify existing indicators, factors, functions and mood categories that have already been identified in the field. The structure of the following subsections will be based on sound categories with the last paragraph containing a brief conclusion and key information for both experimental designs and result interpretations.

2.1.4.1 Music

Whereas some studies have focused on the mood/emotional aspect of soundscapes, other studies provided some direct relations that exist between categorised mood/emotion and sound. Music is commonly associated with expressing emotions. The research by Aiello and colleagues was based on mapping sound information to geographical locations; the findings revealed that streets with music were more likely to be associated with strong pleasant or unpleasant emotions (Aiello, Schifanella, Quercia & Aletta, 2016). In a home environment in contrast, listening to music was found to result in a more positive perception of the acoustic and visual stimuli of the space, together with improved mood states (Steffens, Steele & Guastavino, 2016). Further to the simple pleasures and the unpleasant response of music listening, another study suggested that music could affect the psychobiological stress system and help speed up stress recovery (Thoma, La Marca, Brönnimann, Finkel, Ehlert & Nater, 2013).

Some research also attempted to examine the effect of music through physical installations. In Steele, Tarlao, Bild and Guastavino's study (2016), the installation of an interactive sound system within a public park was proven to alter users' emotional experiences, and contribute to a pleasant and calm perception of the surrounding area. Another study explored the effect of the 'Sea Organ' (located in Zadar, Croatia), an artificial landscape installation that produces music-like organ sound through the action of sea waves. The study revealed that the sea organ, although consisting of a high rating of objective parameters (i.e. acoustic energy, spectral properties, fluctuations and tonal properties) which would suggest a negative perception for an acoustic environment, was perceived as the most positive environment (in terms of appropriateness, expectations and overall perception sound environment) from among other locations in Zadar (Jambrošić, Horvat & Domitrović, 2013).

Some studies focused on brain activities during music listening. For example, a study revealed that music timbral and musical pulse and tonality activated different cognitive circuits (Alluri, Toiviainen, Jääskeläinen, Glerean, Sams & Brattico, 2012). Music timbral would trigger activities in the cerebellum, sensory cortical area, and default mode network cerebrocortical areas. Musical pulse and tonality would activate cortical, subcortical cognitive, motor and emotion-related related circuits. This result suggests that the musical feature of pulse and tonality would have a greater effect on mood/emotions than timbral (Alluri et al., 2012).

2.1.4.2 Human sound

Human sounds are very common in urban as well as some other environments (e.g. hospital wards). Human sounds are usually associated with eventfulness within an urban context. (Axelsson et al., 2010; van den Bosch, Andringa, Post, Ruijssenaars & Vlaskamp, 2018; Viollon & Lavandier, 2000). Axelsson and colleagues discovered that human sound in an urban context not only indicated human activities, it also weakly but positively correlated with pleasantness. This positive correlation was also found in other studies (Aiello et al., 2016; Dubois, Guastavino & Raimbault, 2006). Other studies indicated that human sound did not significantly affect soundscape preference (Liu, Kang, Behm & Luo, 2014).

Most studies consider human sounds as being associated with urban space. Beyond urban contexts, however, the human sound in some cases was observed to have a negative effect. One study observed that a historical location with dominant human sound had a negative effect on perceived soundscape quality (Pérez-Martínez, Torija & Ruiz, 2018), suggesting that the effect of soundscape on mood/emotions is affected by the environmental contexts as well as sound types. Moreover, other findings have indicated that people using hearing aids would also have a negative perception (annoying) towards the human voice (Skagerstrand, Stenfelt, Arlinger & Wikström, 2014). To what extent does the human voice itself contributed to such perception is unclear, but it is obvious that social demographical factors would have an impact on the emotional perception of soundscapes.

2.1.4.3 Natural sound

Natural sound is extensively studied in soundscapes and results general agree that natural sound is very well accepted in terms of perceived pleasantness (Guastavino, 2006; Pérez-Martínez et al., 2018). A study by Axelsson, Nilsson, Hellström and Lundén (2014) identified that the perceived magnitude of natural sound enhanced the subjective soundscape qualities. Natural sounds were also reported to be generally prefered in an urban square context with some variation between different age groups (Yang & Kang, 2005b). Furthermore, the effect of natural sound is beyond pleasantness improvement. Some studies suggested that natural sounds contributed to mood/emotional recovery. In a mood recovery study, participants were presented with a stress-inducing video that elicited discomfort and negative moods; subsequently during the mood recovery period participants were presented with one of the following sound stimuli: natural sound; natural sound with voice; natural sound with motorised sound; or no stimulus. The results indicated that natural sound, compared to other accoustical stimuli or stimulus groups, does show an enhanced mood recovery speed. (Benfield, Derrick Taff, Newman & Smyth, 2014). Another study used a similar design, an arithmetic task as a stress inducer, and skin conductivity levels as the stress recovery indicator(Medvedev, Shepherd & Hautus, 2015). The results of this study supported the findings of Benfield et al. (2014) with further physiological evidence. The restorative nature of natural sound was also found in the relaxed-stressed semantic scale where the sound moved the perception of soundscape towards a relaxation of the scale (Mackrill et al., 2014). Although it was found that natural sound has a general association with pleasantness, this pleasantness was also found to be affected by social demographical differences. Yang and Kang (2005b) found that among different age groups, the preference towards quiet natural sounds, and appreciation of the sound, increasd with age; this increase was especially obvious with elderly people around the age of 60 (Yang & Kang, 2005b). Some studies have suggested that the effect of natural sound might not be all positive. One study revealed that natural sound had no significant effect on mood/emotions after performing a mental arithmetic task, instead they discovered that natural sound with high acoustic variation such as bird sound could impact the performance of the task negatively (Newbold, Luton, Cox & Gould, 2017). This result suggests that the effect of natural sound comes from the acoustical variation of the matural sound. Result also indicate high acoustic variation has the potential to interrupt conscious mental processes and more importantly the positive effect of natural sound might not be an inherent property of the natural sound.

2.1.4.4 Water sound – natural sound

Water sound is one of the most discussed sounds in the study of natural sound. Water sound is also associated with pleasantness (Pérez-Martínez et al., 2018) and eventfulness (Jeon, Hong, Lavandier, Lafon, Axelsson & Hurtig, 2018), as a type of natural sound. Some water sounds (e.g. river) also reveals a restorative effect towards stress recovery and mental energy in terms of recovery speed (Jahncke, Hygge, Halin, Green & Dimberg, 2011). Water sound is not only associated with positive perceptions but also negative perceptions. Rådsten Ekman, Lundén and Nilsson (2015) found that soft variable sounds produced by small fountains evidenced a high temporal variability associated with the pleasant rating of the soundscape, whereas steady-state sound produced by high flow-rate fountains was associated with the unpleasant rating of the soundscape. The results of this study suggested that the steady-state water sound is inherently unpleasant. Jeon et al. (2018) gained a similar result where they found low-temporal variability, high-energy and high-frequency water sounds to be associated with an unpleasant perception of the soundscape. Both studies indicated that pleasantness was not necessarily an innate feature of water sounds, but rather was dependent on the temporal variability of the sound.

Other studies have pointed out that the positivity of water sounds could be misleading, as they found that the positive effect of water sound was not a direct result of the sound itself but rather the masking effect provided by the sound. Axelsson et al. (2014) found that the positive soundscape quality rating of a park was the result of how much the audibility of the fountain sound affected the audibility of other sounds (e.g. traffic and other natural sounds). They also found that this masking effect was not the result of sound levels difference (an objective property) but rather the effect of the perceived loudness of the given sound (a subjective property) (Axelsson et al., 2014). A few other studies provided additional information regarding limitation of the masking effect of water sounds. For example, the masking effect provided by water sound was limited to low temporal variability target sound (Coensel, Vanwetswinkel & Botteldooren, 2011). Jeon, You, Lee and Kang (2008) found that the water sound masking effect was most effective when it matched the sound level of the target sound; effectivity received diminishing result when the target sound went beyond 85dB (Jeon et al., 2008). In a later study, they specified that 'stream' and 'wave of the lake' were more effective maskers and clarified that the water sound should be no less than 3dB below the target sound (Jeon, Lee, You & Kang, 2010). Research regarding water sound has revealed that the correlation between sound types and mood/emotions may not be straightforward. As the literature has shown, not all water sound was related to specific emotional outcomes, rather it was dictated by sound properties such as loudness and variability. This also indicated that the effect on emotional responses resulting from the presence of water sound were not caused by the water sounds per se.

2.1.4.5 Bird sound – natural sound

Birds sound is another natural sound that has been widely studied, and has been observed in association with pleasantness and eventfulness in natural sounds (Hong & Jeon, 2013; Jeon et al., 2018). In Hao, Kang and Wörtche's (2016) study they found that bird sound as a masker for traffic sound, its loudness and occurrence rate, had a significant effect on perceived pleasantness, annoyance and naturalness of a soundscape. This effect on perceived soundscape quality was, however, only significant in low sound level traffic environments (42.5 to 52.5 dBA), whereas, for a noisy traffic environment (57.5 to 67.5 dBA), the loudness and occurrence rate of bird sound evidenced small to no effect on the soundscape quality (Hao et al., 2016). In another study, it was found that bird sound could significantly improve pleasantness and eventfulness of the traffic soundscape of roads with different traffic volumes (3,700 vehicles/h, 600 vehicles/h and 100 vehicles/h), whereas fountain sound only improved the pleasantness of the road soundscape with low traffic volume (100 vehicles/h) (Coensel et al., 2011). Notably ,the result of the limited effect of fountain sound may be due to the steady-state sound used. Nevertheless, this might indicate that bird sound has a stronger effect compared to other sounds (such as water sound) in terms of improving the perceived quality of a soundscape. Different from water sound, bird sound did not appear to significantly correlate with soundscape feature such as spatial and temporal variation (e.g. near and far, steady and smooth) (Pérez-Martínez et al., 2018). Bird sound was also associated with heath anxiety (referring to fear caused by the misjudgement of bodily change or feelings) (Abramowitz & Braddock, 2008). Dzhambov and Dimitrova (2014) found that the ‘appreciation of bird songs’ was one of the significant predictors for health anxiety, but the predictive power depended on a person’s ‘awareness of natural experience’. This indicates that awareness of stimuli could have a significant influence on the effectiveness of detecting mood/emotional outcomes.

2.1.4.6 Traffic sound

In soundscape studies, traffic sounds were usually targeted as a negative sound that needed to be mitigated, avoided or masked (Axelsson et al., 2014; Schreurs, Koeman & Jabben, 2008). Water sound (Rådsten-Ekman, Axelsson & Nilsson, 2013) and bird sound (Coensel et al., 2011) are the two most common sounds used as a masker for traffic sound. Traffic sounds are often perceived as unpleasant (Szeremeta & Zannin, 2009). Depending on the predominance of the traffic sound in an environment, traffic sound can also be perceived as neutral (Kogan, Arenas, Bermejo, Hinalaf & Turra, 2018). Some studies have even indicated that traffic sounds exhibited an association with vibrancy (Cain et al., 2013), which is a combination of pleasantness and eventfulness if interpreted through PCM. It is clear that despite the generally negative perception of traffic sound, traffic sounds can also apparently be perceived as neutral and positive under some particular circumstances. Some studies have indicated that this bipolar nature could depend on the sound level of the traffic sound. For example, in Öhrström’s (2004) study regarding traffic and annoyance, the sound of traffic was observed as the major factor of annoyance. However, In another study of the masking effect of bird sound for traffic sounds, Hao et al. (2016) found that when the targeted traffic sound above 47.5 dBA was perceived, the pleasantness of the environment decreased sharply regardless of the masking effect. They also found that when the traffic sound was above 57.5 dBA the masker was no longer effective in terms of decreasing perceived annoyance and instead increased the perceived annoyance of the sound environment. Similarly, Jeon, Lee, You and Kang (2010) found that half of the people in their study found short term traffic sound to be highly annoying (above the scale of 72 over 100) when the sound level was around 70-73 dBA and regularly annoying (above the scale of 50 over 100) when the sound level was around 66-67 dBA.

Within the finding of the association between traffic sounds and annoyance, some other factors other than sound level has also been discovered. Although it is generally agreed that traffic sound is one of the most annoying sounds in an urban setting, the degree of its effects does vary across environmental context differences, such as perceived annoyance is lower in urban green space compare to neighbourhood streets (Rey-Gozalo, Barrigón-Morillas, Montes-González & Atanasio-Moraga, 2018). In a study considering aircraft sound, Bartels, Márki and Müller (2015) found that the number of flyovers (occurrence rate) of aircraft was a better predictor for perceived annoyance compared to the sound level. However, the results from Sato, Yano, Bjo, Rkman and Rylander's (1999) study showed no significant correlation between the occurrence rate of a road traffic noise event and perceived annoyance, and a strong relation between annoyance and loudness (measured by A-weighted equivalent continuous sound level). Based on the two contradictory results a hypothesis can be made, where sound type difference (in this case road traffic and aircraft sound) can be substantial within the same sound categorise, the major predictor of related mood/emotions could be different as a result. The low frequency of the traffic sounds is another factor that has been identified to significantly affect the perceived annoyance. Persson-Waye and Rylander (2001) confirmed that people exposed to traffic sounds dominated by low-frequency noise were more likely to be annoyed. Nilsson, Andéhn and Leśna (2008) found that barrier filtered traffic sound evidenced a higher level of perceived annoyance compared to non-filtered traffic sound, suggesting that this higher level of annoyance be associated with a higher relative level of low-frequency noise. Besides acoustical factors, Öhrström (2004) found that vibration and dust odours as a result of the presence of traffic also contributed to the perceived annoyance of an outdoor area. This again implies the importance of environmental context in the interpretation of mood/emotions.

2.1.4.7 Summary

An overview of the soundscape literature in terms of sound categories revealed that pleasantness and eventfulness were the two commonly used emotional dimensions but the literature also showed that these two dimensions were insufficient to explain all aspects of emotional response in soundscapes. Although calmness was mentioned in one study, the dimension can still be explained through the combination of pleasant and uneventful. Positive and negative perceptions were also commonly mentioned as part of the mood/emotional response, however, the description was too vague for mood/emotion types and more in line with the pleasantness emotional dimension. It can be seen, then, that the emotional dimensions used in the literature were very limited (as discussed in Section 2.1.2). In terms of mood/emotional categories, stress, anxiety and annoyance have been explored in some studies. The former two categories were related to stress recovery use of nature sounds and annoyance was largely related to traffic sound. The correlations also suggested that certain significant relations might exist between the mood/emotions categories and sound categories. The mood/emotional response in the reviewed literature were mostly self-reported.

Five factors affect mood/emotional response, as identified in the extant literature. This included sound levels, environmental contexts (audio, visual, and functions of locations), demographical differences (age and gender), temporal variability of sound stimuli, occurrence rate of sound events, and type of sound (beyond and within sound categories). These factors are explored with consideration of the categorised mood/emotions in the following studies (Chapters 4, 5 and 6) of this thesis.

2.1.5 Methods of emotional examination in soundscape

2.1.5.1 Recording of emotional response

Several methods can be used to observe an emotional response, including the observation of facial expressions (Ajaya, Peckham & Johnson, 2016; Russell, Weiss & Mendelsohn, 1989), monitoring of physiological changes (Alluri et al., 2012; Di, Fan & Lin, 2018; Hume & Ahtamad, 2013) and self-reporting questionnaires (Pawłaczyk-Luszczyńska, Dudarewicz, Waszkowska & Sliwińska-Kowalska, 2003; Searight & Montone, 2017; Wyrwich & Yu, 2011). Although the former two methods can avoid the potential of mislabelling or misinterpreting emotional responses by participants, they are insufficient at distinguishing emotions beyond the obvious types. Facial expressions can be used to identify rough categories including pleasantness, unpleasantness, or anger, but they cannot be used to distinguish subcategories such as depression or frustration. It is virtually impossible to quantify an emotional response based on facial expressions and emotional responses are not always expressed through facial expressions (Ajaya et al., 2016). Additionally, the observation of facial expressions also introduces a subjective aspect, as the method requires the experimenter to interpret participants' facial expressions subjectively. The physiological response provides objective bodily changes such as heart rate, skin conductivity and brain waves, but in most cases it is hard to correlate these changes to specific emotions as many emotions share the same physiological responses. Additionally, physiological methods require equipment directly attached to or adjacent to participants and introducing laboratory contexts that are hard to ignore, thus breaking the simulation illusion of acoustic environments. This would arguably create a biased result in contrast to natural emotional responses. Differing from facial expressions and physiological changes, the use of self-reporting questionnaires means there is no need to introduce distracting laboratory equipment (visual stimuli) and it is easier to distinguish different type of emotions because the emotional types can be specified based on questionnaire design. Moreover, with the implementation of self-rating and open questions, not only can participants' emotional responses be quantified, the appraisal of the environmental context from participants can also be identified.

2.1.5.2 The insufficiencies of soundscape method

Some studies from the extant soundscape literature, have implemented methods such as forcing participants to evaluate sound clips or sound environments through audio replay. This type of method ignores peoples' implicit emotional reactions to the environment. Other studies have attempted to avoid the issue of consciousness or explicitness by adopting the behaviour observation method (Aletta, Kang & Axelsson, 2016; van den Bosch, Welch & Andringa, 2018); however, this approach could introduce the Hawthorne effect, where participants change their behaviour when they know they are being observed (Lecompte & Goetz, 1982; Monahan & Fisher, 2010). Implementing an implicit (emotional) process bypasses personal opinion bias and improves quantitative data; thus, although emotion is key to soundscape perception, most research has treated emotion as a product derived from reacting to the environment. This notion of emotion as product has hindered the soundscape field's ability to systematically understand emotion and emotional responses, as the emotional response involve a complex process of environmental appraisal.

In the field of soundscape, subjective experiences and cognitive perceptions have been widely studied (Alimohammadi, Sandrock & Gohari, 2013; Botteldooren, De Coensel & De Muer, 2006; Dubois, Guastavino & Raimbault, 2006; Fan, Thorogood & Pasquier, 2017; Hall, Irwin, Edmondson-Jones, Phillips & Poxon, 2013; Hume & Ahtamad, 2013; Jeon et al., 2010; Steffens, Steele & Guastavino, 2017). Many studies have applied self-evaluation methods based on *pleasantness* and *eventfulness* ratings. These methods were developed based on the PCM (Axelsson et al., 2010). However, the PCM is not sufficient when considering distinct emotions and emotional process (see also discussion in Section 2.1.2).

2.2 The emotional approach – the appraisal theory

Based on the extant literature, soundscape has only discovered a small number of the emotion-related dimensions, namely pleasantness, eventfulness, familiarity, interest, understanding, calmness and vibrance. Moreover, only two of the dimensions appears to be found consistently across the studies. Other dimensions such as familiarity, interesting and understanding were only explored in a limited number of soundscape studies, whereas calmness and vibrance dimensions were rather just different interpretations and perspectives of the same pleasantness and eventfulness dimensions. This begs the question: why have only a few emotional dimensions been discovered? Why have the ones that have been found (other than pleasantness and eventfulness) had such a limited implication in the numerous soundscape studies.

Traced to the source, pleasantness and eventfulness dimensions were adapted through Russel's core affect (Russell, 2003), which is the development of the concept of emotional valence and emotional arousal (Mehrabian & Russell, 1974). Valence represents the individuality aspect of the emotions, determining whether an emotion is positively perceived or negatively perceived. Arousal, on the other hand, represents the intensity of a given emotion, determining how strong emotions are felt by individuals (Mehrabian & Russell, 1974; Russell, 1980). Based on the description, it is rather clear that between the two dimensions valence is the more dominant one in differentiating the mood/emotions as it does this through perceived positiveness or negativeness. The arousal dimension as emotional intensity fell short, for example, when dealing with the same mood/emotions with different intensity. The valence and arousal model appears to be logically sound, however, is rather oversimplified to classify all existing mood/emotions. For instance, stress and depression are both perceived as undesirable emotions and can vary along the axis of arousal (intensity), but the two emotions are two very different mood/emotions. This indicates that although valence and arousal are good at differentiating mood/emotions from desirable to undesirable, they lack in the ability to further differentiate mood/emotion beyond intensity. This also helps to explain why pleasantness (valence) and eventfulness (arousal) are found consistently in most soundscape studies, as to differentiate emotional perception based on positivity and negativity is rather preliminary in terms of categorisation.

The other research field that has encountered similar issues is that of emotional research. The same two emotional dimensions, pleasantness and activation (arousal), were found consistently across different empirical studies, whereas other discovered emotional dimensions rarely appeared consistently across all of the studies at all (Smith & Ellsworth, 1985). Smith and Ellsworth stressed that the core of the issue lay with what made mood/emotion has such a variety. The appraisal theory adopts an alternative approach, by considering the person-environment relationship as the main theme of the emotions. This theory considers that each emotion category has a core person-environment relationship theme. More specifically the relationship considers a given environmental context or event and its relation with a person’s goal. In appraisal theory, emotions are represented by a series of appraisal patterns, each distinct emotion is produced through a series of distinct appraisal pattern, and this relation is consistent (Lazarus, 1991a; Roseman, 1984). This implies that mood/emotional responses do not have a direct relationship per se, rather a direct and consistent relationship with the interpretation of the environment (Roseman, 1984). This may also explain the inconsistency of perceived sound quality across different studies when regarding the same sound environments. The difference in interpretation for an environment is partially due to individual or group differences caused by the situational relevance and/or social and cultural backgrounds (see the Section 2.2.1.2 for motivation).

2.2.1 The cognitive-emotional-relational model of appraisal

In Lazarus' (1991) study of appraisal theory, he developed an appraisal model consisting of three main theoretical constructs: the person-environment relation; the motivation; and the cognitive construct. The model provides a relatively comprehensive explanation for appraisal theory. Most literature concerning appraisal before and after Lazarus's study can find its basis in these three constructs. In a simplified form, the model sees the emotions as the results of evaluating adaptational encounters, where the evaluations are based on whether the encounter has significance over personal goals.

2.2.1.1 The person-environment relationship

Lazarus stressed that person and environment cannot be used separately when interpreting emotional outcomes, but rather a relational meaning is emphasised in appraisal theory (Lazarus, 1991). An environmental context or event may have some inherent characteristic that could trigger a certain reaction of an individual, but without the individual's interpretation (appraisal) a mood/emotion cannot be formed. For instance, a slight (belittle or looking down to) towards a person is commonly perceived as inherently negative, but this is only when the person takes it as being offensive and personal that it becomes an insult and, as result produces anger as an emotional response (Lazarus, 1991, p.90, pp. 217-234). The following situation is commonly seen on a comedy set where a joke is aimed at satirising a situation and some individual mistook it for a personal attack, resulting in angry responses in the form of a social media riot. An emotion loses its meaning when the environmental factors disconnect with the human factors; it also loses its meaning when the people disregard the environmental factors (Lazarus, 1991). Another aspect of the relational construct in appraisal theory is that emotion is not the result of passive reaction but the active appraisal of the environmental context or event (Lazarus, 1991). A simplified statistical analysis disregarding the qualitative factors, then, cannot sufficiently reproduce such relationships, as it only considers the reactional aspect (a simple causal relation) of a relationship. A simple causal relationship disregards the reason why a positive or negative response appears. A more effective analysis should also account for the individual's active appraisal of the environmental factors in the form of actions or wish to pursue or avoid an outcome in relation to his/her goals.

Despite appraisal models emphasising person-environment relations, there is the situation that powerful environmental or personal factors can dominate emotional outcomes. For example, experience of military events has a strong association with emotional dysfunction (Bih-Ching & Drph, 2002). Other situations such as the loss of loved ones or situations that endanger one's life, cannot be easily dismissed by individuals. Factors such as strong social perceptions or collective cultural differences can overshadow the less dominant individual differences. Conversely, a strong personal want or goal may also dictate one's perception, making an individual more likely to appraise an event according to his/her desire, despite the inherent characteristics of the event.

2.2.1.2 Motivation

The motivation of appraisal theory indicates the amount of effort people are willing to spend and the strength of the emotions generated, both of which are positively correlated with goal commitment activated in an environmental situation. According to Lazarus (1991), motivations could be considered in two ways: personality traits; and reactions to environmental conditions. Although the environmental relationship is the one that has a closer relationship with soundscape studies, it is difficult to understand one without the other as the two are intercorrelated with each other. In the sense of personality traits, motivation represents a person's want or aversion in relation to values and goal hierarchies in a giving event (Lazarus, 1991, pp. 92-104). It helps an individual to evaluate whether an encounter is beneficial or harmful. The strength or importance of a personal goal is represented by the energy or resources that a person is willing to spend to pursue it. As a result, the more important the goal is, the stronger the emotion it produces. It is important not to confuse this with personal value, which only represents whether something is desirable or undesirable but does not refer to any actions. Personal value can be illustrated in a scene where one considers doing something is good, but due to circumstantial limitations one is not encouraged to do so. As result, personal values are less intense compared to personal goals. The idea of goal and value, although it can represent what one desires, does not indicate how much resources a person is willing to offer to achieve them. The 'how much' of the effort is explained through the idea of *goal commitment.* This term gives meaning to a good or bad experience and, in turn, represent the ways and purpose in life for people (Brickman, 1987). Understanding of the goal commitment relies on an understanding of the goal hierarchies. The hierarchy consists of a horizontal structure represented by relations among the goals such as achievement and ego-identity, and a vertical structure concerned with the relationship between a person's narrow goals and global goals (Lazarus, 1991, pp. 92-104). An example could be that different people may share a similar long-term goal, such as a successful career, some may see a single failure in work as detrimental whilst others will simply dismiss it due to the difference in narrow goals. This example demonstrates two different motivational commitments with the same horizontal structure but differing vertical structures. Further, the motivation related to personality traits also differs in terms of self-attribute motive and implicit motive. On the one hand, self-attributed motives represent surface beliefs about the desired goals that correlate with conscious concern to improve the situation to achieve them. Implicit motives, on the other hand, are mostly unconscious and likely have a long term effect on people's mood/emotion developments (McClelland, Koestner & Weinberger, 1989). Regarding the relation between motivation and environmental conditions, motivation is when opportunities (to benefit or damage one's goal) are presented by an environment, and how the environment then motivates a person to commit effort to engage with the conditions (Lazarus, 1991, pp. 92-104). In this sense, a person is reacting to an environment and only when the environment is relevant to the person's goal (personality-trait) can the person be motivated to commit resources to utilise the opportunity presented. There are two distinct meanings of motivation involved in this type of relationship. The first is the motivation to appraise whether a condition is good or bad for the relevant goals. The second is the motivation to adapt to this new condition (Lazarus, 1991, pp. 92-104). The distinction between the two meaning is directly related to the distinction of the variables and processes found in this type of emotional encounter.

The personal goals as the main part of the motivation construct vary from group to group, person to person, and even time to time for an individual. The differentiating factors can generally be summed up in two types: the psychobiological difference; and the differences caused by social development. Although from the perspective of psychobiology it is more likely to have universal goals due to similarity in the development process within a species (such as the universal pleasantness or unpleasantness found in certain emotions), there are individuals with significantly different physiological features. Whether the differences are inherited or developed later in life, an individual could develop different personal goals as a result of these differences. In terms of the differences caused by social development, it is more likely for a group of people to develop different goals systematically, due to cultural values and social structures within a social group. However, this does not imply that different encounters of life events between individuals in the same society should be ignored (Bergman & Magnusson, 1979). The importance of the difference in goal diversity has a direct contribution to the variability of mood/emotional outcomes.

2.2.1.3 Cognitive activity

The third theoretical construct of appraisal is cognitive activities. Where the appraisal is identified as the process of obtaining meaning from a given environment, there are two sides to the equation. One is the objective environmental reality, and the other is subjective personal interest to complete the transition from environmental reality to personal interest, where the cognitive activity – appraisal is required (Lazarus, 1991, pp. 133-152). Striking a balance between the environment and personal factors is crucial to the foming of rational responses. The objective conditions of a given environment are enormous and more often than not contains many aspects. As such, a person cannot possibly make sense of all parts of the environment, and this is where the personal interest comes in, to allow the person to appraise according to personal need and want. This is demonstrated in Paterson and Neufeld's (1987) study of the reality-testing process in dangerous conditions. However, the above process only explained rational mood/emotional response to the world, not the irrational kind. For irrational responses, one of the likely explanation would be the result of false belief or understanding of the objective conditions produced through appraisals based on the false knowledge of a condition (Henle, 1962). Additionally, an unbalanced appraisal between the objective environment and subjective personal factors often result in an unhealthy perception of the world and therefore unhealthy emotions. One study found that people with a more realistic view of their situation were more likely to be depressed (Alloy, Albright, Abramson & Dykman, 1990). Alloy and colleagues explained that depressed people were likely experiencing the absence of optimistic bias and a distortion of reality. In a sense, this means that people who suffer from depression have an overly objective appraisal of their condition and lacking in the focus of personal factors. Conversely, overly focusing on personal factors such as personal-control and responsibility could also lead to stress and depression (Mirowsky & Ross, 1990a), as an environment is usually difficult to fully control by a person with limited resources. Although having control over a situation is generally favoured by people, there are exceptions (Folkman, 1984). When a situation is outside a person's control and when it's attributed to others, this could result in feelings of calm and relief as there is no responsibility.

To understand how the appraisal process operates, Lazarus (1991, pp. 152-168) distinguished two kinds of appraisal in terms of orders. The *primary appraisal* is the judge of an environmental condition and whether it has the potential to affect personal goals, and the *secondary appraisal* considers how a person should react to the condition to obtain or avoid such effects. Lazarus (1991, pp. 152-168) also pointed out that the appraisal operated in two ways: an automatically and unconscious way; and a deliberate and conscious way. He stressed that cognitive appraisal related to emotional response was more likely to be an unconscious process, due to the short response time; however, given enough time people would naturally reappraise a situation (Ledoux, 1989), leading to more complex logical thinking. Despite being relatively irrational, fast and operating below the level of awareness, the automatic way of operation is capable of complex appraisal processes through the form of emotional memory (Ledoux, 1994). It is also worth pointing out that the conscious way of the appraisal process may produce conflicting emotions that differ from the prior automatic process (Roseman & Smith, 2001), and emotions produced through such conflict may appear unreasonable or irrational from an outside perspective. By reviewing the extant appraisal theory literature, it is rather clear that the adaptation role of appraisal as a cognitive activity is to balance the objective environment and subjective personal factors. It is through this process that appraisal can obtain meaning from an objective environment to form mood/emotional responses.

2.2.2 The process and structural model

Many models have been developed based on the appraisal theory, and can be mostly categorised into two types: the Structural Model; and the Process Model. The focus of the structure model is mainly on what are appraisals. The model explores the composition of the appraisal process, types of appraisal, appraisal patterns and how they relate to specific emotions and environmental encounters. The process model emerged following development of the structural model as the natural development of appraisal theory, with the aim to explain operation mechanisms and the procedure of the appraisal process.

Appraisal components (or appraisal dimensions) are the basic unit at which the mood/emotional processes operate. Each appraisal component answers a specific question during an encounter of an event, for example, is an environmental encounter beneficial or detrimental to the current goal of an individual? The development and examination of appraisal components are crucial to understanding the emotional process and this has been one of the focus of many studies regarding the structural models (Roseman, 1984; Smith & Ellsworth, 1985). One of the other key contributions of the structural model to emotional study is the core relational theme (Lazarus, 1991a; Smith & Lazarus, 1993). To represent a specific emotion several appraisal components are required, providing a pattern of appraisal components for an emotional response. These patterns are the core relational theme and are consistent for specific mood/emotions.

The process models of appraisal were developed to address the issue where structural models proved lacking, mainly the operation mechanisms underlying the appraisal process. The primary issue regarding the process model attempts to address was whether the appraisal process operated under consciousness or unconsciousness. The aforementioned cognitive-emotional-relation model (Lazarus, 1991) is a good example of the process model. In his model, Lazarus clarified that although the appraisal process appeared seemingly complex and cognitively intensive, it did not require great deals of conscious effort if at all. The meaning of ‘unconscious’ in the appraisal study implies that a cognitive process can be outside of awareness, to prevent emotional distress that might have been caused by it. The concept of the ‘unconscious’ partially stems from Gillett’s (1990) study of anxiety, in which he proposed that to elicit anxiety through ego-defence the triggering of the defence itself was not required, and that merely motivating the defensive effort was sufficient. Similarly, Lazarus argued that the same could be applied to any emotions, and the unconscious triggering through a cue rather than going through the entire cognitive process was made possible due to people having already learned the complete cognitive process; later in life, then, a cue allows a person to skip the process and directly produce the emotional response (Lazarus 1991, pp. 152-168). In the same research, Lazarus also stressed that the conscious and unconscious appraisal process could coexist, although he did not explain the mechanism. This mechanism was susbequently explored in Smith and Kirby’s (2001) process model. In the model, one mode of cognitive process is *associative processing* where the automatic cognitive processes are prime and activated through the memories. The other mode is *reasoning*, where controlled and deliberate thinking takes place. They proposed that the two modes involved in the appraisal process progressed in parallel through a distinctive feature that developed in the model, called the *appraisal detector*. This feature can integrate the information produced in both models to produce a final emotional response. Importantly, the information and person-environmental relationship produced through reasoning could be stored in memory and later activated through the associative processing mode unconsciously. One addition to the process model, to recall Lazarus's (1991) proposed distinction of primary and secondary appraisal (see Section 2.2.1.3), is in which the primary appraisal evaluates the initial engagement of the environmental encounter and judge whether the encounter is beneficial or detrimental to a person. Both Lazarus (1991) and Smith and Kirby (2001) agreed that this stage of the appraisal was unconscious due to its primitive nature. The model of Smith and Kirby demonstrated a very dynamic emotional response process and answered why the emotional response mostly appeared unconscious.

2.2.3 Categorical and continuous aspect of the appraisal

The category of mood/emotion was defined through the difference of core relational themes (Lazarus, 1991a; Smith & Lazarus, 1993), in other words the difference of contained appraisal components. Most importantly, the categorical boundary presents in any bipolar appraisal components (Roseman & Smith, 2001). For example, motive-congruence and motive-incongruence should be considered as two separate categories instead of two ends of the same dimension. The boundary between the bipolar appraisal components cannot be crossed, as a specific emotion cannot include both sides of the appraisal. However, this does not mean that emotion does not vary within a broad category. These sub-categorical difference in emotion are caused by the intensity difference of the appraisal components included in those categories (Roseman & Smith, 2001). The example of this difference is quite common between emotions that share similar appraisal components: happiness and pride both share pleasantness, low level of effort, high level of certainty, strong desire to attend to situation and self-responsibility and control as appraisal component. The differentiating factor is that the sense of self-responsibility control is much higher in pride.

2.2.4 The unconscious Jazzercise effect and mood

The Jazzercise effect is the theory proposed by Jenefer Robinson (2005) that offers a relatively complete explanation of how music affects human emotions. The theory was developed base on the summarisation of the mechanics of emotion contagious (explains a situation where people automatically mirror another persons' expressed emotions) (Hatfield, Cacioppo & Rapson, 1993):

1. People tend to synchronise their movement, facial expressions, voice and postures automatically with each other during conversation conditions.
2. Subjective emotions are constantly affected and modified by these mimicry activities.
3. Because of these mimicry activities, people tend to 'catch' each other's emotions every moment.

The Jazzercise effect argues that music with emotional characteristic can directly affect the bodily system. Without people consciously evaluating the music they hear or feel the expression of emotions from the performers (Robinson, 2005). According to Robinson, the emotional responses elicited through the Jazzercise effect are more close to moods, and that they did not trigger through appraisals. Moods could lower the threshold of entering an emotional state (Ekman, 1994; Frijda, 1993), and could also change one's judgments about themselves. In a mood-induction experiment reported by Scherer and Zentner, listeners were asked to evaluate their specific qualities, such as 'how smart are you?'. The results showed that people rated their quality higher after hearing 'happy' music rather than 'sad' music. Scherer also commented that this effect was stronger when the listener evidenced low self-esteem (Scherer & Zentner, 2001).

Although Robin posited that music affected the motor and other bodily systems directly, she also acknowledged that emotion caused by the Jazzercise effect could coexist with the emotions caused by a conscious evaluation of music (Robinson, 2005, p. 395). In Robins' summary, the reason music makes people happy is that "music with happy, sad, calm, or restless character cause physiological changes, motor activity, and action tendencies, that are experienced as happiness, sadness, serenity, or restlessness" (Robinson, 2005, p. 395).

2.3 Appraisal theory and soundscape

The relationship between soundscape and appraisal is integrated and the hierarchical position of the two can be switched based on the perspective of studies. In an emotion-focused study, sound sources and their corresponding environment context are part of the objective encounters, and when appraised by a person would produce emotional responses to assist to better the persons' current conditions. In a soundscape focused study, the emotional responses are one of the factors that affect the perceived soundscape quality. Between the two disciplines, the appraisal emphasises the process of the emotion, whereas the soundscape leans towards the emotional outcomes and how it affects the subjective evaluation of a soundscape. Furthermore, based on the appraisal theory, the subjective evaluation of soundscape may produce further emotional responses, hence creating a continuous cycle of processes. This continuous process renders the hierarchical differentiation between soundscape and mood/emotions (such as the one suggested in ISO 12913-1:2014) somewhat meaningless and may be potentially misleading when studying such relationships. Therefore, it is important to view the relationship between soundscape and emotions as a part of an integrated system.

2.3.1 The person-environment relationship in soundscapes

At its core, the study of soundscapes is the study of the relationship between sound environments and the person who observes them, with emphasis on the subjective evaluation of the environment, rather than the objective property of the sounds or contexts. This relation is similar to the person-environment relationship suggested by Lazarus (1991) in appraisal theories. Lazarus suggested that emotion was the manifestation of the changing person-environment relationship – if the relationship changed so to did the emotion. In soundscape studies the person-environment is more specific. The ‘environment’ is the acoustic environment, the ‘person’ are those people who perceive the acoustic environments, and the ‘emotional reaction’ is the subjective perception of the environment.

There are two points emphasised by this relationship that emotion-related soundscape studies can reference from. The first point is the importance of individual interpretation. This idea stems from the separation between the cognitive activities of knowledge and appraisal. Knowledge in this context explains the understanding of the operation mechanism of the world. This can either be a general concept and beliefs of the world and oneself (Epstein, 1983; Gilbert, 1991), or the specific knowledge regarding specific situations (Lazarus 1991, pp. 133-152). As Lazarus explained, knowledge on the one hand cannot produce mood or emotions as they lack subjective appraisal. Appraisal, on the other hand, provides the individual interpretation of the knowledge, therefore producing emotional outcomes (Folkman, Schaefer & Lazarus, 1979). This separation between knowledge and appraisal is also presented in soundscape studies. Examples such as the general knowledge of traffic sound as negative per se (Axelsson et al., 2014; Schreurs et al., 2008) and natural sound as positive per se (Guastavino, 2006; Pérez-Martínez et al., 2018) does not produce an emotional response. It is only when a person evaluates such sound according to his/her well being that one can determine whether or not it was a positive or negative response. This also explains the situation where some people's evaluation of a sound subverts the general evaluation of a sound type due to situation difference such as task performing (Newbold et al., 2017) and individual differences such as age (Yang & Kang, 2005a, 2005b).

The second point that emotion-related soundscape can reference is that emotional response requires active evaluation of the event rather than a passive response. In the case of soundscape studies, the active appraisal of sounds and their context is required to produce an emotional response. However, 'active' here does not refer to consciousness; the act of appraising can still largely proceed unconsciously (see Section 2.2.2). An understanding of this active role of appraisal in mood/emotion generation means that the difference in subjective soundscape quality caused by individual or group differences can be analysed through appraisal models. Specifically, the difference in results can suggest the underlining importance of the stimuli to the person or group's well being.

2.3.2 Why emotion forms - motivation in soundscapes

The motivation construct in appraisal theory should operate similarly in the soundscape study, where the acoustic environment and its contexts may provide opportunities to better or damage one's goals. These opportunities motivate people to commit resources to respond to them. The motivation constructs emphasise the relevant aspects, specifically how is the opportunity provided by the acoustic environment relevant to the perceiver's goal. The appraisals of the given opportunity at the core are the *motivational relevance* (is the opportunity relevant to perceiver's goals) and *motivational consistency* (does the opportunity benefit or damage the perceiver's goals) (Smith & Lazarus, 1993). Only when the acoustic environment is relevant to the perceiver's well being can the emotional response be produced. The motivation constructs help to understand the interest of perceivers through the resulting soundscape quality and, in turn, may provide a community-focused or personalised soundscape design strategy. In terms of research studies, the motivational difference or similarity between individuals or groups provides a theoretical explanation from an emotional perspective. Results such as the universal reaction towards a certain type of sound, e.g. natural sound (Guastavino, 2006; Pérez-Martínez et al., 2018), or group differences due to different collective cultural and social groups can all obtain new insights through motivational difference.

2.3.3 How emotion forms in soundscapes

According to appraisal theory, for any environment to affecting one's emotion, it has to be relevant to his/her well-being. In soundscape, this means that the acoustic environment could either be improving or disrupting people's goal. An example of a short term goal could be activities such as relaxing improved by sounds stimuli through distracting people from stressful matters. In a non-activity specific scenario, people's mental health, for example, could be affected by the acoustic environment. In a common acoustic environment such as an urban setting, sound stimuli are usually observed unconsciously as background. This suggests an emotional process involving environmental sounds are most likely unconscious as well. Based on the Jazzercise effect, in this type of encounter, the acoustic environment is most likely to have altered people's moods. Moods are very vague and non-object related emotions and related to people's general life situations (Lazarus 1991, p. 48). It is unlikely that an acoustic environment is the cause of a mood, however it could raise or lower the threshold to arouse the acute emotions to their related mood (Ekman, 1994). It is expected that most of the natural emotional responses in a soundscape in such a manner are due to soundscapes' ambient nature, however, this does not mean all emotional responses in soundscape are unconscious. Neither do all unconscious responses affect moods instead of acute emotions.

Another context that emotional responses are involved in the soundscapes is where there is a clear object relation between acoustic environment and personal well being. These situations are mostly presented when an individual undertakes activities or performing tasks, in which the acoustic environment may assist or disrupt such activities or tasks. As there is an immediate goal involved, instead of mood, acute emotions are likely to be generated. If an appraisal process is learned in the past and ingrained as emotional memory, the related acute emotions can be generated unconsciously through an environmental cue skipping the appraisal process (Lazarus 1991, pp. 152-168). It is important to notice that the acute emotion produced in this way may not be reasonable for every encounter, as the encounter related to the original emotional memory may not be the same as the actual environment encounter but merely the best match of the situation from an individual's experience. This unconscious process and its bias can be illustrated in the example of a fountain's sound in an urban setting; this may be appraised by an individual as pleasant due to his/her experience. However, the fountain sound may interrupt conversations between the individual and his/her friends. Therefore, the unconscious pleasant response is unreasonable. In this example, it would require further conscious effort to re-appraise this new situation to produce a more reliable emotional response. A conscious appraisal process appears when individuals have been given enough time to re-appraise an environmental encounter through logical reasoning. In soundscape, this would require individuals to focus attention on acoustical and environmental stimuli and devote conscious effort to assess the protention effects on his/her current activities. Therefore, the acute emotions produced consciously are highly personalised and environment-specific.

2.3.4 What emotion forms in soundscapes

Based on appraisal theory, emotional outcomes are based on appraisal patterns presented during the forming process (Frijda, 1986; Lazarus, 1991a; Roseman & Smith, 2001). Although predicting every possible appraisal component in a soundscape encounter is unlikely, there are still patterns to follow. The appraisal components can be roughly separated into primary and secondary appraisals. On the one hand, as primary appraisals mostly deal with the motivations of individuals in the encounters (Lazarus 1991, pp. 152-168), primary appraisals can largely define positivity (motivated to engage) or negativity (discouraged to engage) of the outcome emotions. Secondaries appraisals, on the other hand, deal with how individuals respond to the motivations, such as who is responsible for the encountered situations or how much effort would one willing to commit to the opportunity or threat (Lazarus 1991, pp. 152-168). Therefore, secondary appraisals differentiate emotional outcomes beyond positive and negative. Pleasantness and unpleasantness responses are common response in soundscape studies, however, other emotional types are rare and inconsistent across these studies. This lack of variation in emotion could partially be the lack of involvement of secondary appraisals in soundscape studies. The focus of the secondary appraisals would provide soundscapes with the ability to explore specific emotional types in depth.

Another factor for the outcomes of emotions is the environment. The environment in the soundscape is unique, as the soundscape mostly considers acoustic environments. Sounds are at the centre of the environment and other aspects serve as the context of the soundscape. The most common soundscapes include urban space and city parks (Axelsson et al., 2014; Jeon et al., 2018), road-side pedestrians (Hao et al., 2016; Paiva, Regina, Cardoso, Henrique & Zannin, 2018; Sato et al., 1999), and hospital wards (Mackrill, Jennings & Cain, 2013; Mackrill et al., 2013, 2014). These specific environmental setting are most likely to produce specific emotional responses. Therefore the environmental aspect should be explored in relation to the emotional process.

2.3.5 The explicit appraisal process

The explicit appraisal process explains the emotional process in an environmental encounter where people make a conscious effort and have explicit thoughts about environmental stimuli, for example, is an environmental encounter beneficial to an individual’s current goals, or is an environmental encounter against an individual’s ego identity? These thoughts then form a unique appraisal pattern for a distinctive or non-distinctive pattern of emotional responses.
In soundscape studies, the explicit thoughts of perceivers about an acoustic environment can be both towards sound stimuli and/or its related contexts. For a person to explicitly appraise an acoustic environment, they must be exposed to the stimulus for a certain amount of time, as cognitive effort and time spent are factors affecting the conscious appraisal of an environment (see also the discussion in Section 2.2.1.3). This is in direct contrast to the appraisal process if it is occurring unconsciously, which is very brief. The time required for the conscious process to happen varies from situation to situation, but one study suggested three to five minutes appears to consistently make such an appraisal (Folkins, 1970), and the longer the time the more likely for such a conscious appraisal to appear. As there are many environmental factors present, it is difficult to state which aspects a person will focus on, therefore, the conscious appraisal of an acoustic environment is very subjective in terms of emotional outcomes. Additionally, even if people focus on the same environmental elements, their individual relationship with these elements might still be very different, and as defined by the appraisal theory, the different person-environment relationships dictate which emotion is produced as a result (Lazarus 1991, pp. 89-127). Based on these different individual

appraisals, it is expected that most of the individual variation in emotional response will be the result of the explicit appraisal process.

In an uncontrolled environment such as on the streets, an urban pedestrian will not be appraised consciously based on common aspects of urban sounds such as people speaking and traffic sounds. The sound stimuli that have the greatest potential for conscious appraisal are the sounds that stand out and interfere with a persons' goal, such as sirens that interrupt a person's thoughts, or a street performance that catches their attention. Therefore, if people are forced to appraise an acoustic environment explicitly, it would produce biased results via neglecting the unconscious appraisal of the environment. This bias can be created in controlled environments if people are specifically asked to appraise environmental stimuli.

2.3.6 The implicit process

In contrast to explicit appraisal, the implicit process explains the emotional processes requiring little or no conscious effort. There are two types of implicit emotional process: the first involving appraisal of the environment, and the second elicited through motor mimicry of the Jazzercise effect. The first appraisal process is completed automatically without conscious thought. This automated process takes place due to the triggering of emotional memories (emotional memories are the memories of an experienced emotional process) (Lazarus, 1991a; Ledoux, 1994). This memory allows people to skip the entire appraisal process and produce a direct emotional response.

The second types of implicit processes are the ones produced through the Jazzercise effect, as explained in Chapter 2 (see also Section 2.2.4). This process alters moods rather than acute emotions through the effect of music on bodily systems without involving any appraisal of the environment. Robinson (2005) explained that mood altered through the Jazzercise effect is different from the emotions (both moods and acute emotions) triggered through emotional memory. Although it is unclear what exact aspects of sounds, for example music, is the cause of such an effect, it most likely involves the function of motor mimicry. As previously discussed (see Section 2.3.3), a mood is the product of a person's general life situations (Lazarus 1991), and it is unlikely that a single event or a simple change of bodily system is the sole cause of such mood. What is most likely is that the Jazzercise effect has intensified or attenuated the current mood of an individual. This also provides an additional argument that there are no appraisals involved in the Jazzercise effect.

Two types of implicit process (the automated process and the Jazzercise effect) are expected to play a major role for soundscapes to produce an emotional response, as it is relatively rare to have a logical conscious appraisal of ambient environments such as acoustic environments. One of the key points of these types of emotional response is that it happens very fast and if a person has been given sufficient time to reflect on the appraisal process, it would likely become an explicit one.

2.4 Conclusion

Certain soundscape studies have explored the various aspects of emotions. However, most of the results were limited to the pleasantness and eventful dimensions, and any results beyond the simple positivity or negativity of the emotions appeared to be inconsistent and fragmented across these studies. On the one hand, this was largely due to the lack of in-depth theoretical structures besides the PCM; the PCM is known to have difficulty distinguishing between specific types of emotions. On the other hand, appraisal theory provided a thorough explanation for the emotional process from the perspective of the person-environment relationship, and the emotion types could be distinguished from each other through distinctive appraisal patterns. Additionally, appraisal theory's emphasis on the person-environment relationship made its adaptation to soundscapes suitable, as the soundscapes are also concerned with the relationship between environment (with emphasis on sound) and person (subjective perception of sound).

The review of the extant soundscape literature here has provided evidence that current soundscape studies lack a systematic understanding of emotional responses. A theoretical foundation is required to provide such understanding. Implementation of appraisal theory would provide such a foundation to systematically explore the relationship between emotional process and soundscapes. Appraisal theory has also made answering the question of how soundscapes affect emotions feasible. It is a hypothesis that the interaction between the soundscape and emotional responses is similar to the person-environment relationship provided in the appraisal theory. With the perceiver of the soundscape as the 'person' side of the relationship and all the acoustic and non-acoustic environmental factors as the 'environment' side of the relationship. To verify this hypothesis, the question of how soundscape is affecting emotional responses (specifically distinctive emotions) was set out. Further, the experiments were designed with the notion that a specific objective (to establish a controlled person-relation) was proposed to participants. The first step would be to identify and examine the environmental factors involved in soundscapes and that participated in the emotional processes. This should be done in an in-situ environment and was the focus of the first study (see Chapter 4). The second and the third step for providing a systematic understanding of emotional responses in soundscape would be to further examine those factors found to have had a significant effect on emotional responses in in-situ environments. These factors were sound types and environmental contexts. The examination of the two factors should be in a controlled environment and was the focus of the second study (see Chapter 5) and the third study (see Chapter 6), respectively. Results of the studies should be examined based on the person-environment relationship corresponding to specified emotions, and whether the interpretation of the result fits established emotions.

Chapter 3 Methods

The previous chapter reviewed current literature in both the soundscape field and emotional response studies from the field of psychology. The literature revealed that current soundscape studies lack a systematic understanding of the emotional processes underlying the subjective response to acoustical environments. Additionally, the current soundscape methodology is insufficient in analysing distinct emotions. It was concluded that introducing theory and methodology from psychological studies (i.e. appraisal theory) would help soundscape to have a better understanding of emotional outcomes in acoustic environments. Following the conclusion from the literature review, this chapter reviews and explains the methodologies applied in the three main thesis studies. The chapter also explains how appraisal theory has been integrated into soundscape studies.

Figure 3.1 demonstrates how the research aims and methods are correlated.

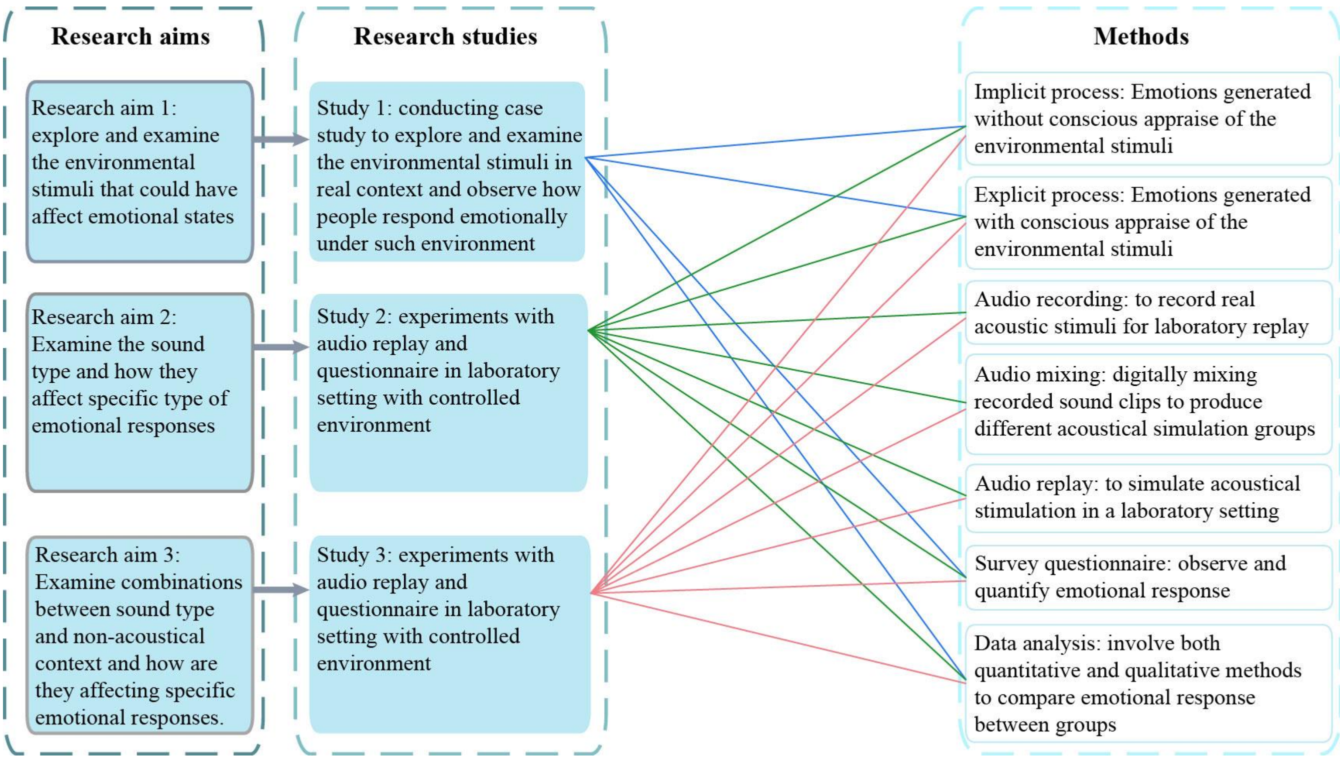

Figure 3.1 Methods used in the thesis and their correlation with the each research question (main research study)

3.1 Standard procedures in soundscape research

Based on the ISO/FDIS 12913-1 (2006) and ISO/FDIS 12913-2 (2013), soundscape studies should always consider the three key components of people, acoustic environment, and contexts of the studied environment. People (participants) as the perceiver of the studied soundscape, the procedure of their recruitment, their relationship with the study environment, and social-demographic information should be recorded. Types of acoustic environment, types of sound sources including total sound, background and foreground sound should be identified and recorded. The choice of acoustic and psychoacoustic indicators should be appropriate to reflect the studied environment. Context information other than acoustic should also be recorded, this includes: weather conditions, time of day and year of recording sessions, the position of the measuring device (including height and orientation of the recordings). Beyond the information of the three key components, the method used for data collection should also be explained. This includes the questions or questionnaires used and how they were formulated and what language was the survey conducted in. Any additional information that has the potential to influence the subjective interpretation of the acoustic environment should also be reported.

This standard procedure in soundscape research methods was mostly followed in this thesis (for detailed methods used in each study see section 4.2, 5.2 and 6.2 of respective chapters). However, as the focus of this thesis study is the emotional responses of experiencing an acoustic environment, conventional psychoacoustic indicators and questionnaires were insufficient to examine distinctive emotions (such as anger). To detect and record the emotional responses that existed in an acoustic environment, a questionnaire was derived from the field of psychology. Profile of mood states (POMS) typically used to examine emotional state was implemented in this thesis study (see section 3.5 and 3.6 for a detailed explanation of the questionnaire and its underlying categories).

The following sections explains the methods and tools universally implemented in this thesis study for simulation and examination of the studied acoustic environment (urban public space).

3.2 Audio recording, audio mixing and audio replaying

Methods of audio recording, audio mixing and audio replay were implemented in this thesis to replicate and simulate the audio stimuli of an in-situ acoustic environment (i.e. urban public space) in a controlled environment (i.e. laboratory) (These method is related to thesis study in chapter 5 and 6). The reason for recording audio clips on-site rather than mixing existing audio files was that most existing audio files, particularly those that include certain types of sounds are very ‘clean’. In other words, they do not contain ambient noise that is a combination of unidentifiable or hard to identify sounds in an existing environment. Examples of ambient noise include a combination of the sound of wind blowing through trees and human movements. In an audio clip, these ambient noises are usually removed to create a clean sound file. However, the removal of ambient noise also removes the acoustical context from the sound that the recording aimed to capture. Therefore, audio clips recorded in this study had specifically maintained the ambient noise together with any identifiable dominant sounds. Additionally, the inclusion of such an acoustical context also made the comparison between the results of the in-situ case study and laboratory experiment more reliable, as both cases included the same stimuli and acoustical contexts.

The purpose of the audio mixing was to create audio stimuli for control and compare groups. To create audio clips with specific sound types, however, audio recording as a stand-alone method is insufficient, as this requires combinations of two or more recorded audio clips. A simple mix of two sound types may produce an unusual sound combination and feel out of place. Further, audio clips like this would attract the attention of listeners, therefore creating a bias by increasing the possibility of explicit appraisals in a laboratory setting. However, as previously mentioned, the inclusion of ambient noise would provide audio context for such sound combinations. An example of this kind of sound clip was the mixture of music and traffic: a direct combination of the two may feel strange but with the ambient noise of pedestrians, the sound clips would feel like a street performance next to a busy street.

Finally, audio replaying (or listening) was the final step to present acoustic stimuli to participants in a controlled environment. On the surface, this method implies the involvement of acoustic stimuli only; however, to fully simulate an acoustic environment it was important to include non-acoustical stimuli, mainly visual. Evidence exists that visual cues can have a significant effect on perceived soundscape quality when presented together with sound stimuli (Pheasant, Fisher, Watts, Whitaker & Horoshenkov, 2010; Watts, Khan & Pheasant, 2016; Yang & Kang, 2005a). As it was unreasonable to recreate the original scene of the sound stimuli in a controlled setting, the best way to present visual stimuli in the laboratory would been through the use of picture projections of the scene. The reason for not using video recording as visual stimuli was that video replay in the laboratory might result in too much distraction from the audio stimuli; further, visual and audio stimuli in combination reduce conscious perception of each other (Southworth, 1969). As the focus of this thesis was on soundscape and acoustic environment, the potential effect of visual stimuli was minimised by using still images rather than moving pictures. In addition, the audio stimuli in this thesis were played through speakers instead of headphones. Although the use of headphones would provide be more ‘true’ to the source audio stimuli in terms of the quality of the sounds, the act of asking participants to put on a headphone would be no different from asking participants to consciously appraise the audio stimuli. As previously discussed, this would create bias by neglecting the implicit process in the emotional responses. Therefore, speakers will be used for the audio replay, thus maintaining the possibility for implicit processes to take place.

3.3 Questionnaire

The emotional process consists of triggering, monitoring, and labelling (Robinson, 2005), and is mostly subconscious until the labelling stage. Emotions can remain undefined (unlabelled) if the person is unaware of the physiological changes occurring. A soundscape is often not consciously perceived, meaning that mood responses can remain at the emotion monitoring stage and not arrive at the labelling stage. The implementation of the questionnaire has helped participants recognise and label their emotions.

The questionnaire in the following thesis studies consisted of a quantitative section (self-rating scales) and a qualitative section (open questions). The quantitative self-rating scales have allowed changes in a specific type of emotion to be observed and analysed statistically. The statistical analysis has enabled the observation of the degree of the emotional changes, and whether the change was positive or negative. The quantitative section of the questionnaire provided reliability in the study results, as the increase or decrease of intensity of the emotional responses can be observed accurately through quantitative data (see also Section 3.7.1 for an explanation of how the quantitative data was analysed). The qualitative open questions served two purposes. The first purpose was to identify the environmental elements that have been the focus of participants during their emotional processes, in-order to understand how and why the specific emotional response has formed. The second purpose of the open questions was to identify which process (i.e. implicit or explicit emotional process) that the emotional response has been produced from. For example, if participants focused attention on the specific environmental aspect and had logical thoughts about it, the process would likely be explicit; if participants had no specific thought about the environment, the process would likely be implicit. The qualitative open question section was implemented to provide supplementary information for the quantitative results, and as such cannot define the outcomes of an emotional response alone. The qualitative data provided information to deduce the possible appraisals presented in an emotional response based on a person's attention on environments, and to identify whether the emotional response was rational or irrational. This approach reduces the subjective bias of the self-reporting methods (see also Section 2.1.5.1 for an explanation of how the qualitative data was analysed).

3.3.1 The Profile of Mood States (POMS) questionnaire

The POMS questionnaire was used for the quantitative self-rating scales. The original questionnaire was developed by McNair, Lorr and Droppleman (1992). POMS is commonly used in medical contexts to monitor patients' emotional states over time and has been extensively tested in different populations (Shin & Colling, 2000; Terry, Lane & Fogarty, 2003; O'Halloran, Murphy & Webster, 2004). The questionnaire uses 65 words/items (with 7 redundant words) and can be separated into 6 broad emotion/mood categories. This includes: anger (12 words); confusion (7 words); depression (15 words); fatigue (7 words); tension (9 words); and vigour (8 words). Each word/item is rated on a 5-point Likert-type scale from '1: not at all' to '5: extremely'. The thesis studies used a 6-point continuous scale to ensure suitability of the data for statistical analysis and to prevent participants' tendencies to select the middle rating (Van Heerden & Hoogstraten, 1979). From the perspective of the appraisal process, a 'mood state' (one of six broad emotional categories) referred to in the name of the questionnaire is not mood per se, but rather explaining a collective of a subcategory of emotions that share similarity in terms of appraisal components or expression of types of person-environment relationship. Therefore the term 'mood states' will not be used beyond referring to the POMS questionnaire to avoid confusion.

POMS was also supported by the Semantic Differential Measures of Emotional State, a self-reporting measure (Mehrabian & Russell, 1974) for the three emotional dimensions: pleasure, arousal, and dominance (referred to as PAD). Many words in this list are similar to those of POMS and fall into the POMS categories of tension, depression, anger and fatigue. All matching pairs are shown in Table 3.1 POMS, as a semantic scale, enables a statistical analysis of its numerical results, reducing potential personal interpretation bias compared to qualitative data (Aletta et al., 2016).

Table 3.1 PAD and POMS semantic scales: Matching items

PAD	Pleased-annoyed (Pleasure)	Stimulated-relaxed (Arousal)
POMS	Annoyed (Anger)	Relaxed (Tension)
PAD	Hopeful-despairing (Pleasure)	Frenzied-sluggish (Arousal)
POMS	Hopeless (Depression)	Sluggish (Fatigue)
PAD	Relaxed-bored (Pleasure)	Wide awake-sleepy (Arousal)
POMS	Relaxed (Tension)	Fatigued (Fatigue)
PAD	-	Excited-calm (Arousal)
POMS	-	Active (Fatigue)

Note. PAD: pleasure, arousal, and dominance; POMS: Profile of Mood States; Brackets indicate which dimensions (of PAD) or mood category (of POMS) the items match with.

The current POMS was deemed sufficient for this study. Therefore, the questionnaire was not modified in order to maintain internal consistency.

The reason for utilising POMS as the rating scale of the studies here was that the questionnaire included multiple emotion categories (the six broad categories) and each category also included a variety of subcategories (items under each of the six categories). Furthermore, an existing questionnaire with extensive testing provided good internal consistency and validity, which was more efficient and robust than developing new scales. One thing worth mention was that POMS contains more negative emotion categories (five out of six) than positive emotion categories (only one out of six). The underlining goal here was to explore the relation between soundscape and emotions, more specifically the relationship between appraisal patterns and acoustic environment in specified emotional types.

The positive or negative categories were not important, what is important was how and why each of the appraisal components appears in an acoustic environment.

As the POMS questionnaire contains large numbers of items (65) and a liker-scale questionnaire, there were concerns about the order effect. The order effect can occur in an experiment when multiple stimuli are being examined, and the presence of previous stimulus affects participants' response to the next, hence creating biases in the data collected (Fotios & Houser, 2009; Poulton & Poulton, 1989). To prevent such potential bias, all the surveys sessions conducted in this thesis were designed to include only one stimulus and there were no repeated measures (i.e. any one participant was only recruited for a single survey session). Similar prevention procedures were also suggested by Poulton and Poulton (1989).

Another other issue with the POMS questionnaire was that the many items making up the questionnaire had the potential to cause participants to lose attention and/or misinterpretation the items given. Although this thesis did not specifically include attentiveness checking questions in the experiment design, the resulting data (of chapters 4, 5 and 6) were checked through principle component analysis (PCA). Assuming the data had measured the same underlying factors, the results of the PCA of the three chapters should be comparable without large deviation from each other (the detailed PCA results please see sections 4.3.6, 5.3.5 and 6.3.5).

3.4 Emotion (Mood) categories

This thesis emphasises the study of individual emotions and their relationship with acoustic environments. This was all based on an understanding of appraisal theory. Therefore, the emotions selected should be analysable through appraisal theory. This included any typical emotions that can be clearly defined by appraisal theory and emotional related concepts which take part in the appraising process. This thesis adopted the POMS questionnaire (which includes six emotional categories, all analysed through the lens of appraisal theory) to ensure they were suitable for the course of the studies. Each of the six categories was analysed in terms of their distinct core relational themes and appraisal pattern if they were typical emotions. If they were emotional related concepts, how they are involved in the appraising process and how could they affect or help the emotion forming process were analysed.

3.4.1 Anger

Lazarus (1991) developed and defined the core relational theme of adult human anger as that of a "*demeaning offense against me and mine*". Lazarus emphasised the 'offense' aspect of the anger, explaining it as a disregard or harm in one's identity (a type of goal in appraisal theory). The appraisal components included in the appraisal pattern of the anger emotion include 'goal relevance', 'goal incongruence', and damage to self-identity ('ego-involvements') as primary components. The secondary components include *accountability* of oneself or others, imputed *control* of the situation. The first four components are necessary to distinguish anger as an emotion. The last two appraisal components, *coping potential* and future expectation, are not necessary to form anger but often appear in anger emotions. The *coping potential* of anger favours attacks on the others who have caused harm in one's ego-identity, and the *future expectation* would assess whether the environment would respond favourably to the action of such an attack (Smith & Ellsworth, 1985; Lazarus, 1991).

Goal relevance and goal congruence/incongruence are the two appraisal components always present in the appraisal pattern of emotions and moreover, they are straight forward. If an environmental encounter is relevant to one's goal then emotion is associated; if it is irrelevant, then no emotion is associated. In the appraisal pattern of every emotions, there is always goal relevance. For goal congruence and incongruence, if an environmental encounter is congruent to one's goal then the emotion is favourable; conversely, if incongruent then the emotion is undesirable. The ego-involvement in anger emotion as emphasised by Lazarus (1991) is the subjective perception of the offense to oneself. Smith and Ellsworth (1985) also made a similar observation, other's unfair treatment towards a person had a negative impact on that person. The appraisal components 'accountability' and 'control' are both dealt with whether the situation is to do with oneself or others. In anger, both components are directed towards others, where someone besides oneself is held accountable to cause harm to him/her and this external subject is expected to have the ability to avoid such situations but did not do so. Smith and Ellsworth (1985) also pointed out that the aspect of other's responsibility is key to distinguishing between anger and other negative emotions. However, the blame in anger is not limited to the person but also to objects, such as societal danger or body of an unfair system, since the concept of fairness and integrity are also part of the ego-identity (Hamilton & Lerner, 1982). In the case of anger towards an object where there is no person to blame, the blame is often attributed to the unfairness of systems or organisations. The appraisal components of coping potential and future expectancy are to do with how people respond to an emotion. In anger, a person favours attack as responding to the person who is responsible for the negative situation. What is important is that this attack does not necessarily require actions (verbal or physical) but merely action tendencies. Future expectancy, in contrast, asks the question of whether an action of attack has any future consequence: if it is safe to do so, then the act of attack would likely be carried out; if not the action tendency would likely be suppressed. All the appraisal components provide a unique appraisal pattern for anger to be generated. As anger is one of the most common emotional responses in human experience, an acoustic environment may provide context that contradicts a person's goal, and one of the examples would be interrupting a person to relax. This potential of interruption of a person to perform an activity caused by external sources provides a good environmental foundation for anger to be generated. Therefore anger was suitable for this study.

3.4.2 Tension (Anxiety)

In the literal sense, tension refers to psychological stress. According to Smith and Kirby (2001), psychological stress indicates high goal relevance and low goal congruence. The intensity of psychological stress is indicated by goal commitment. This was proved in an empirical study where the difference between the strength of psychological stress reactions towards different goals was indicated by the difference of a person's commitment towards said goals, and the stronger the commitment, the stronger the stress. In the case of the empirical study by Smith and Kirby (2001), the goals were a person's achievement and the goal relevance is the environment in relation to their achievement. As explained previously in Chapter 2, goal commitment represents how much effort one is willing to put in to achieve the goal. It can be used to predict the strength of emotional response; hence, it can be a good indication of a person's intensity of psychological stress. There lies the problem, however, as under appraisal theory all negative emotions contain the appraisal components of goal relevance and goal incongruence. In this sense, psychological stress is an emotional response but not a specified emotion category. Instead, psychological stress can lead to other more specific emotions such as sadness and fear (Smith & Kirby, 2001). Based on the items presented, the *tension/stress* emotional category that the POMS questionnaire references, is not psychological stress but anxiety. Whereas anxiety is often used as a synonym of stress, the reason the word tension is used as the emotion categories for POMS could be the similarity in terms of appraisal component included, as shown in the next paragraph.

The core relational theme of anxiety is the 'uncertain, existential threat' of a person's ego-identity (Lazarus, 1991). Lazarus emphasised that the uncertainty and anticipation of existential threat and uncertainty of what and when such threat would come to represent the uniqueness of the anxiety as emotion. The appraisal components that entail the anxiety are goal relevance, goal incongruence and protection of ego-identity against existential threat (ego-involvement) (Lazarus, 1991). The appraisal pattern of anxiety is unique in the sense that it does not contain any secondary appraisal patterns, such as coping potential and future expectation. This uniqueness in appraisal pattern, as Lazarus emphasised, comes from the uncertainty of how the environmental encounter is going to unfold. The relatively short appraisal pattern shares similarities with psychological stress with the only difference, the ego-involvement, likely the reason that stress as a word is often used in place of anxiety in terms of verbal expression.

In acoustic environments, unexpected sound when perceived by an individual may indicate a threat on a personal level. Sounds such as alarms, loud noises, and sounds indicating a changing of the environment, could indicate unpredictable threat based on personal interpretation and in turn lead to anxiety responses. Therefore the anxiety emotion (tension) was suitable for the thesis studies.

3.4.3 Confusion

Confusion, as explained by Silvia (2009), is a metacognitive signal that notifies a person that he/she does not comprehend an environmental encounter, and may produce an action tendency to commit more effort to understanding the situation or dismissing it altogether. Based on this explanation, there are environmental events presented in the process of confusion, however, due to the complexity and difficulty in understanding the encounter. One cannot relate the events to his/her goals, hence no goal relevance, goal congruence or ego involvement. Based on appraisal theory, in confusion there is no person-environmental relationship so it cannot therefore be an emotion. This notion was also supported by Lazarus

(1991), that mental confusion is not an emotion per se, but it does produce an action tendency similar to emotion. Despite this notion, mental confusion can involve mental activity due to its action tendency, although this ultimately depends on would a person experiencing confusion is willing to commit more effort and would the person be able to establish a person-environment relation with the event in question after such commitment. If so, a proper emotion can be formed. Nevertheless, if a person does decide to ignore the encounter then confusion will remain a cognitive signal. In this sense, confusion does provide the potential for emotion to form, but it is not necessary for it to happen. Neither can one predict what emotion would be produced if it did occur. In acoustic environments, it is likely for people to hear a sound that one does not understand, as sometimes the source is unclear or the sound is tangled with other sounds. Ultimately, it depends on whether the listeners are willing to find out what the sound is in order to establish a person-environmental connection or not. Under this notion, confusion deserved to be studied under the lens of soundscape but the focus needs to be when confusion does lead to an emotional reaction but not confusion itself. This was also what the thesis studies did.

3.4.4 Depression

The theory of depression originated from the studies of helplessness, where Seligman (1975) proposed that depression could be caused by negative life experiences which resulted from a lack of control in adverse conditions. The earlier theory involving depression focused on the actual helplessness conditions and how people dealt with them. Subsequently, the theory shifted into subjective attribution about helplessness since not everyone responded to the same negative life events with helplessness. As Seligman (1975) explained, helplessness has the aspect of lack of control of the situation encountered and that nothing could be done to change it. This aspect is similar to the emotion of sadness identified by appraisal theory, which has the core relational theme of *irrevocable loss* (Lazarus, 1991). Different from depression, sadness as emotion indicates that an individual has resolved the encounter involving such emotion, accepted the loss and the emotional distress has been dissipated. Depression, on the other hand, indicates that the acceptance of loss has not yet been reached (Lazarus, 1991). Based on appraisal theory, depression itself is not an emotion. First, depression does not has a distinct appraisal pattern, despite its similarity with sadness; the aspect of the 'resolve not yet reached' means there is potential for multiple emotions to be involved, such as worthless, anxious and angry. Second, emotional distress involving depression is a professional judgement based on psychopathology independent from emotions, and as such should not be treated the same (Lazarus, 1991).

In the POMS questionnaire, the depression category is not only represented by a few items (3 words) that directly explain the depressive state, but also mostly items of different potential emotions that depressive states can transition to (12 words), namely sadness, fear, worthless/guilt and anxious. Applied to soundscapes, high depression rating through the questionnaire indicated the presence of the depressive state. The high rating also indicated two potential situations. First, that the environmental stimuli indicated/signified the loss of the individual. Second, the environmental stimuli were the trigger/reminders of a depressive memory. These two situations can be illustrated by examples such as for an individual, intense traffic sounds could indicate the loss of healthy living environments and that seemingly nothing could be done to change it, or reminding one of the poor living conditions that the individual is already aware of. In this sense, the depression category is meaningful for soundscape studies in terms of identifying potential depressive state triggers in an acoustic environment.

3.4.5 Fatigue and Vigour

The feeling of fatigue was proposed by Boksem and Tops (2008) as a result of situations where the total amount of energy spent to achieve a goal exceeded the perceived rewards. This explanation indicates that mental fatigue is involved in the goal achieving process, therefore fatigue is not an emotion but is likely involved in the emotional responses. A similar notion was made by Thayer (1989). When people became fatigued, it was more likely for them to feel anxiety and fear when performing a challenging task. While agreeing with Thayer, Lazarus (1991) added that fatigue in an emotional process could worsen the balance between demand and the coping resource; instead of creating emotional distress, it decreased one's ability to cope. Both Thayer and Lazarus's understanding of fatigue in terms of its effect on emotion is similar, although fatigue itself is not an emotion it can significantly reduce the threshold to experience some emotions.

As a theoretical position, vigour is considered the polar opposite of fatigue (Russell, 1980, 2003), and each is at different ends of the same continuum. The bipolar relationship between fatigue and vigour is also reflected in the POMS questionnaire where the rating scores of the vigour category is reversed (negative value). With this theoretical position, several assumptions regarding vigour can be made based on the understanding of fatigue. First, in vigour, demand does not outweigh the coping resource in an environmental encounter. Second, the threshold of energy spent to exceed perceived rewards is higher, which means that a goal may appear to be relatively easy to obtain compared to non-vigorous states. In other words, people are less likely to be stressed out in a vigorous state, and any emotion that can potentially be manifested from stress (tension) are also less likely to appear.

Vigour and, in turn, fatigue were both proposed by Greene, Elffers, Lingo et al. (2007) as effective states experienced in work-related contexts (goal-relevance) and reflect peoples' resources. This proposal is based on the conservation of resources (COR) theory where the resource is defined as personal energies and characteristics, objects and conditions valued by individuals and can be used to exchange other resources. Fatigued states indicate that the resource spent in a goal pursuing activity has exceeded the potential rewarding resource, where a vigorous state means it has not or at least not yet. In soundscape, if a fatigued state is observed, it indicates that acoustic environments have contributed to the spending of personal resources. In the context of emotions, this means cognitive effort (energy) has been spent on environmental stimuli. However, a vigorous state indicates that cognitive effort has not been spent on environmental stimuli or the amount of effort spent are small and not enough to overthrow the potential reward resource. For illustrative purposes using an example of a person's aims to relax, if he/she ended up feeling fatigued, this meant that the environment included elements that encouraged the person to utilise cognitive effort to process. Conversely, if the person felt energised following a relaxing period and did not spend enough cognitive energy on the shrouding environment or at all, this implies that he/she is well-rested. The inclusion of fatigue and vigour provides potential indicators for cognitive activities. This was useful to understand the formation process of emotion and helps to explain some of the emotion or emotion-related outcomes (i.e. tension and tension related emotions such as fear, anxiety and sadness).

3.5 Data analysis

Data analysis can be generally separated into quantitative and qualitative sections. On the one hand, the quantitative section utilised the quantitative data (rating scores) gathered from the questionnaire has explored and revealed potential variables and emotions. The qualitative data, on the other hand, helped to explain the revealed relationship based on an understanding of appraisal theory.

3.5.1 The quantitative data analysis

The quantitative data refers to the self-rating scores in the questionnaires and these data were analysed through various statistical models to reveal the potential relationship that existed between acoustic environment and emotions. The variables included sound types, sound levels, environmental contexts such as natural light, various visual contexts related to the sound source and contexts of the laboratory setting, and social demographical information such as gender. The emotions were the six categories included by the POMS questionnaire (anger, tension, confusion, depression, fatigue and vigour). The statistical models can be roughly separated into: the initial exploration of the data to provide a general understanding of the relation between emotion and acoustical environment; and subsequent detailed analysis where the relationship of individual variables (e.g. certain sound types) and distinct emotional responses can be explored.

The statistical models involved in the initial exploration were the Mann-Whitney test for the case study and Multivariate Analysis of Variance (MANOVA) for the laboratory studies The Mann-Whitney test was implemented largely due to the uneven sample size caused by uncontrollable on-site environmental conditions and the skewness and kurtosis of the obtained data (see detailed data analysis in each study sections 4.2.6, 5.2.5 and 6.2.7). MANOVA was implemented for the laboratory experiments (Chapters 5 and 6). MANOVA was used due to there being several dependent variables (i.e. the six mood state categories). MANOVA allowed several dependent variables to be examined reliably at the same time, and also allowed the dependent variables to be compared among each other. The assumptions of the MANOVA test include statistical independence in observations, random sampling, multivariate normality and homogeneity of covariance matrices. The former two assumptions were fulfilled through experimental design for the two studies (i.e. non-repeating measures for any one of the participants and no specific demographic groups were targeted). For the latter two assumptions, analyses of normality (through checking kurtosis and skewness of data groups) and equality of variances were performed separately (see detailed analysis in each studies' data analysis sections 5.2.5 and 6.2.7).

The statistical models involved in the subsequent detailed analysis were *simple regression* and *multiple regression* for the case study (Chapter 4); *discriminant analysis*, *factorial ANOVA* with *post hoc*, *simple regression* and *multiple regression* for the laboratory experiments (Chapters 5 and 6). The simple regression case study was used to identify the direction of the effect identified in the initial Mann-Whitney test. The simple regression shows how a dependent variable (i.e. the mood state category) changes with the increase or decrease in independent variables (i.e. the soundscape stimuli such as presence or absence of a sound type). In other words, the simple regression can identify whether the environmental factors add to the intensity of a specific emotion or reduce the intensity of the emotion. The Mann-Whitney test, in contrast, was unable to tell whether a significant change was an increase or a decrease. The multiple regression in the case study provided a comparison among presented environmental factors (variables), whereas simple regression could only examine the relationship between one environmental factor and one emotional outcome. The multiple regression explored the effect among environmental factors in how certain emotions were affected.

In the laboratory studies, discriminant analysis was conducted following the MANOVA test to group the environmental factors by their effect on different emotions and the factorial ANOVA with post hoc to establish one-to-one relationships between sound types and emotion categories. As previously stated, conducting multiple ANOVA tests would inflate the Type I error. However, with the protection of the MANOVA test, such risk can be mitigated. Simple regression tests were conducted to examine the effect of sound level on emotions. And finally, multiple regression was used to examine the effect of some environmental contexts beyond the experimental design (e.g. participants' behaviours and the perception of the physical environment of the laboratory).

3.5.2 The qualitative data analysis

The qualitative data refers to the open questions that followed the POMS questionnaire. The questions were used to extract information about which environmental or non-environmental factors were involved in the cognitive activity or emotion forming process. These qualitative data, as previously mentioned, were used as complementary information to better understand the revealed relationship from the statistical analysis. This explanation was based on the understanding of appraisal theory, more precisely the human-environment relationship presented in an emotional response. For example, anger responses towards machinery sound have been shown in the form of an increasing anger score rating, and a number of participants also reported being distracted by a construction scene. Based on the core relational theme and appraisal pattern of the anger emotion, the construction site and its machinery sound has been perceived to negatively affect personal well-being (goal relevance and goal incongruence), and was caused by others and could have been avoided (attack to ego-identity and blame of others). In this example, the qualitative data provided an additional context for the anger, together with an understanding of the appraisal pattern, they provided an explanation that has a theoretical foundation for how such a relation came to be. Without appraisal theory to predict why such a relation happened, any propositions would only be a best guess based on instincts or life experiences, which would be highly subjective.

3.6 The implementation of implicit and explicit appraisal process

The aim of implementing implicit and explicit appraisal process was to maintain the natural response towards environmental stimuli from participants. As mentioned in section 2.3.5, explicitly asking participants to appraise any environmental stimuli would elicit an explicit appraisal process. This type of experimental design was avoided in this research by limiting the information provided to participants. The key is not to explicitly suggest or establish a connection between environmental stimuli and activities being performed by participants. Hence there was no pre-determined person-environment relationships forced upon participants. Any potential person-environment relationships were established by the participants themselves to maintain a natural response. In terms of the implicit appraisal process, automatic responses in soundscapes depend on how long a person reflects on the encountered acoustic environment. Alternatively, an environmental encounter should not attract the attention of the perceiver hence not result in conscious thought. Since the length of time participants decide to reflect on the environment surrounding them cannot be controlled, the experimental design's focused was to provide a longer time period for participants to immerse in said environment. This longer period allowed the participants attention to flow freely within the environment hence both explicit and implicit appraisal processes could occur naturally.

In term of how to observe and identify such a process, quantitative methods such as self-rated scores were deemed insufficient as they can only represent the change in emotional states but were unable to interpret a person's thought process. However, with the addition of self-reporting (a qualitative method with open questions), it was possible to identify whether the emotional state has been produced consciously or unconsciously. Therefore, hybrid methods of self-rating (ranking items in the questionnaire) and self-reporting (open questions in questionnaire) were used in two of the studies in this thesis (see Chapter 5 and 6).

Chapter 4: Effect of soundscape on mood states in urban pedestrian space: a Sheffield case study

4.1 Introduction

Previous thesis chapters explored and reviewed current literature and methodology from studies of emotional responses in both acoustic environments and from the perspective of psychology. This review led to the conclusion that current theories and methodologies used in soundscape studies are insufficient in establishing a systematic understanding of emotional outcomes. This thesis suggests introducing a new methodology from the field of psychology to help establish a better understanding of emotional outcomes in acoustic environments. Continuing from this conclusion, the chapter then explains and discusses the first main study (Chapter 4) of this thesis. The study is an on-site survey conducted in an urban public area. By integrating the appraisal theory this chapter aims to identify and examine potential environmental factors that significantly affect people's emotional outcomes. The identified factors not only provide preliminary data for the following studies of this thesis (Chapter 5 and 6) but also an initial test for the viability of integrating appraisal theory in a soundscape study.

The study found that environmental condition, such as weather and (air) temperature, did not significantly affect participants' emotional outcomes. The sound type and physical contexts however showed significant but varied effects on emotional outcomes. The statistical outcome of these results was discussed and analysed through the lens of the appraisal theory (an emotional model from psychology).

The list of research objective were as follows:

- Identifying environmental conditions that have the potential to affect mood/emotional response;
- Identifying sound types that present within an urban public context;
- Identifying sound types that elicit a significant mood/emotional response; and

- A preliminary data analysis of any identified factors (sound types and environmental conditions) in relation to mood/emotions.

4.2 Methods

This study was an in-situ survey conducted in the city centre of Sheffield, UK. Participants were recruited on site based on location and time of occupation. Standard procedure as suggested by ISO/FDIS 12913-2 (2013) and ISO/FDIS 12913-2 (2019) was followed, including: information of participants, acoustic environment, context of the environment where the study was conducted, and questionnaire used.

4.2.1 Elicitation of implicit processes

To capture participants' natural responses, the implicit emotional process was elicited by not allowing them to control or monitor their mood state; the survey did not hint at a relationship between mood state and environmental variables (temperature, light, sound). To prevent participants from assessing the study's goals, they were provided minimal details and no environment-related information.

4.2.2 Questionnaire

POMS (McNair et al., 1992) was employed to bring participants' consciousness to the surface, inciting them to evaluate their emotional process, label it, and convert unquantifiable mood states into statistically comparable data. The questionnaire used a self-report format, which may have introduced bias (See also Section 3.5.1 which introduces the POMS questionnaire and see questionnaire use in Appendix A).

4.2.3 Site and stimuli

The survey took place in five areas within the Peace Gardens (see Figure 4.1 and areas 4 and 5 of Figure 4.3) and Fargate Street (see Figure 4.2 and areas 1,2 and 3 of Figure 4.3) in the city centre of Sheffield, UK. As an in-situ study, it had the advantage of representing a realistic urban environment; however, as a case study, this research only represented the studied location and, as such, may not directly contribute to theory due to the lack of laboratory examination. Hence, this study also provides a reference and contextual foundation for the following two laboratory studies (see chapters 5 and 6).

The Peace Garden is a green public space in front of Sheffield Town Hall, with traffic running north-south on the west side and a quiet pedestrian street to the east. They comprise a sunken plaza, flower beds, central fountain, and stone walls with a built-in, waterfall-like fountain (ranging from 1–2 m high). The sound environment is complex consisting of mixed sound sources and types, including: traffic (dominant foreground sound), fountain (dominant foreground sound), human (quiet background sound), birdsong (quiet background sound) and the sound of children (quiet background sound) (see Figure 4.1).

Figure 4.1 The Peace Gardens’ sunken plaza (top left), street-side (top right), view from inside outward (bottom left) and street side view of the short wall (bottom right)

Fargate Street is a typical commercial pedestrian street (site 2) closed to traffic except at each end (sites 1 and 3), with ground-floor commercial space on both sides and a broad pedestrian area in the middle, where market stalls are typically present during holidays. Busy holiday events and activities also take place here, facilitating the study of human activities (see Figure 4.2). Sound types include human (quiet background sound), traffic (dominant foreground sound), quiet shop music (quiet background sound) and street music (dominant foreground sound). Visual stimuli include ice-cream van and street vendors.

Figure 4.2 Fargate Street, north-end (left), in-street (middle), and south-end (right)

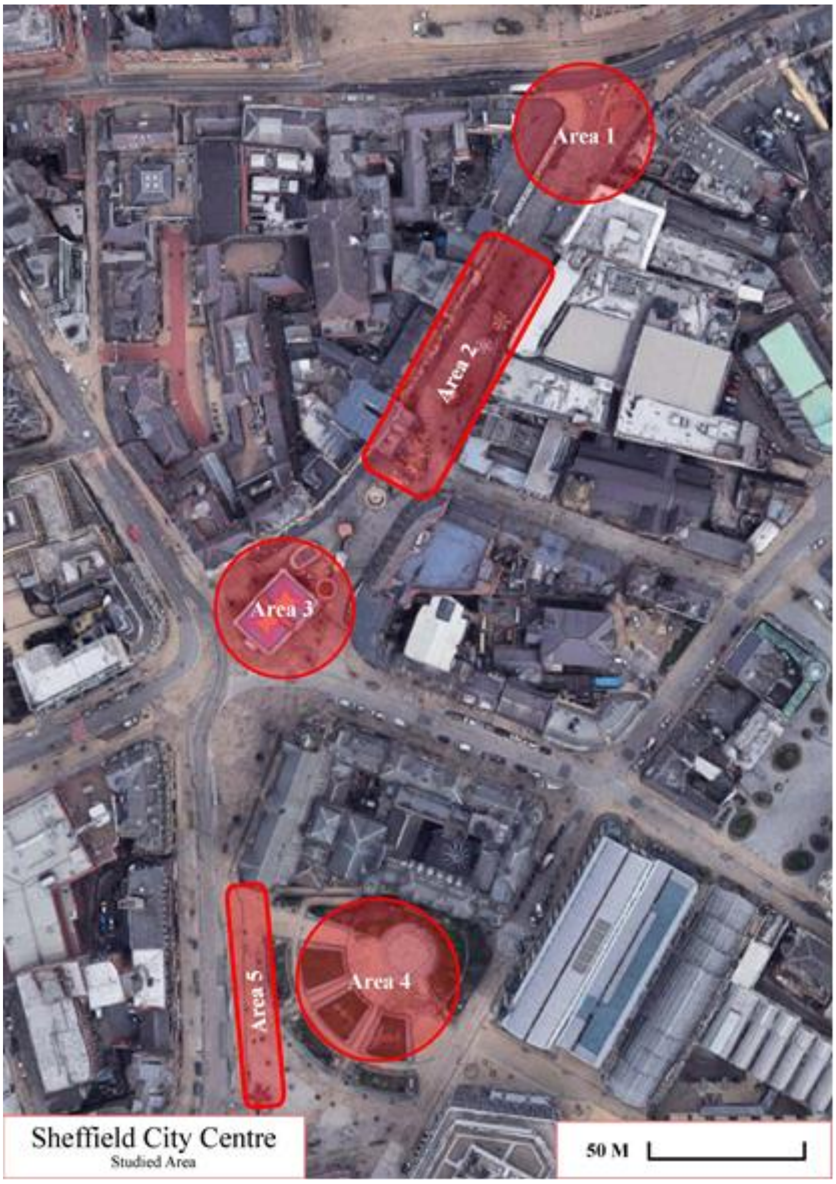

Figure 4.3 Satellite images of site locations. Areas 1, 2, and 3 = Fargate Street; Areas 4 and 5 = The Peace Gardens

4.2.4 Participants

Participant size was calculated using the *G*Power 3.0* software. As participant groups for each soundscape stimuli in this study were mostly based on the presence or absence of a stimulus, usually two groups were present in each comparison, and t-test were considered to be the suitable statistical model to examine the mean difference between two groups. If the data was non-parametric or had unequal participant group sizes, sample calculation with t-test also provided sufficient power for the non-parametric statistical models such as the Mann-Whitney test. Two *A priori* calculations for *t-test for mean* were conducted. One was for equal participant group size, and the other for non-equal participant group size. The equal participant group size calculation showed that to achieve a power of 95% for a medium effect size [$d = 0.5$], a total participant size of 210 was required. The non-equal participant group size calculation (with an extreme group size ratio of 0.2) showed that to achieve a power of 80% for a medium effect size [$d = 0.5$], a total participant size of 226 was required. For easy calculation, 250 participants were surveyed to guarantee a sufficient participant size.

Ethics approval (Reference 013791) was provided by the University of Sheffield. Participants were recruited on-site. The surveyor took up an observation position and looked for any potential participants who were: a) stationary in the site area, either sitting or standing, for a minimum of 5 minutes; and b) with no obstruction in their ears. Potential participants were then approached and asked: i) if they wanted to participate in the survey; and ii) if they had normal sight and hearing. If the participant was willing and fit all the criteria, the survey began; if not, the surveyor returned to the observation position. This process screened for participants who could properly absorb the environment based on the aforementioned criteria. These criteria also dictated the site selection and the acoustic environment of the sites. One important thing to consider is that the participant screening criteria resulted in un-randomised samples. The criteria were there to guarantee the control of participants' goals on-site (i.e. relaxation). As explained in the appraisal theory (see section 2.2.1), the participants' goals affect the emotional outcomes. Hence, randomly approaching people on-site was not possible if such goals were being controlled. People who did not remained on site for an extended period of time would not have the goal of relaxation. Conversely, if people were passing through the site, meaning their goal was to reach another destination, the appraisal of the sites themselves would have been significantly different due to the change in person-environment relationship. The screening itself would certainly produce degrees of sampling bias that would affect the generalisation of the study results. However, such sampling biases were eliminated in the latter laboratory studies (chapters 5 and 6) and can be used for cross-examination for this study. Around 25% of the people approached agreed to participate and were eligible. Participants' ages ranged from 14 to 75 years (M=31.56, SD=13.85); 54.5% were female, 45.3% male, and 1 response had gender information missing (0.4%).

4.2.5 Survey Procedure

The survey was conducted during sunny and cloudy conditions but not rainy weather, as people would be less likely to utilise the open public space to fulfil the function of relaxation. The survey was conducted between 10:00 and 18:00 (Monday–Friday, 14 May–3 July 2018), to include periods of heavy human activity and the ability to observe the daily usage of the space. The survey process has also avoided days with raining and weekend to ensure temperature and density of human activity is relatively consistence. The questionnaire was explained to participants as an instrument to measure how they were feeling at that moment by rating the words from 1 (not at all) to 6 (extremely). Participants were told that the numerical value of the scale was consistent and continuous (e.g. 2 was twice as strong as 1, and that they could write a fractional number, e.g. 1.5, 2.25). The explanations provided were as follow: 'the numbers ranked from 1 to 6 are equal in distance, i.e. distance between 1 to 2 is the same as form 2 to 3'. During the process, the researcher answered any question regarding the survey as long as it did not interfere with the application of the implicit process. Figure 4.4 shows the complete survey process cycle.

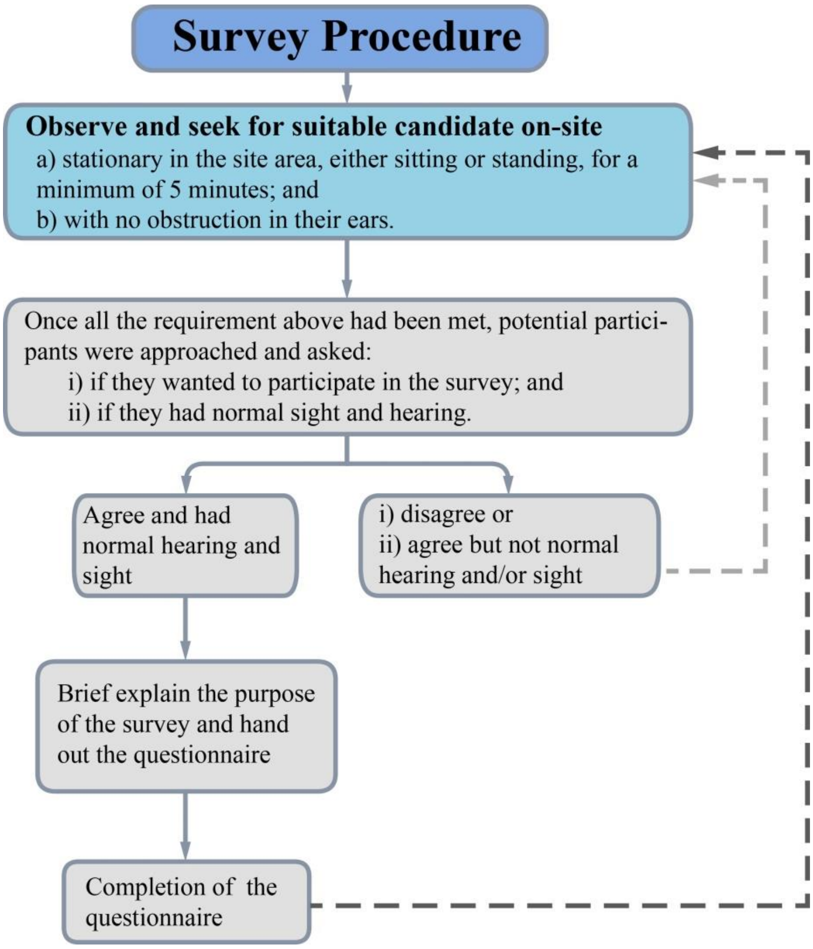

Figure 4.4 Survey procedure cycle

4.2.6 Data Analysis

The study aimed to identify dominant environmental variables within the observed categories that could affect mood states. Due to the large participant size (above 200), the normality test through the z-scores of skewness and kurtoses is likely to produce significant results even in normally distributed data. Instead, the normality of the data was explored through histograms (see Figure 4.5)

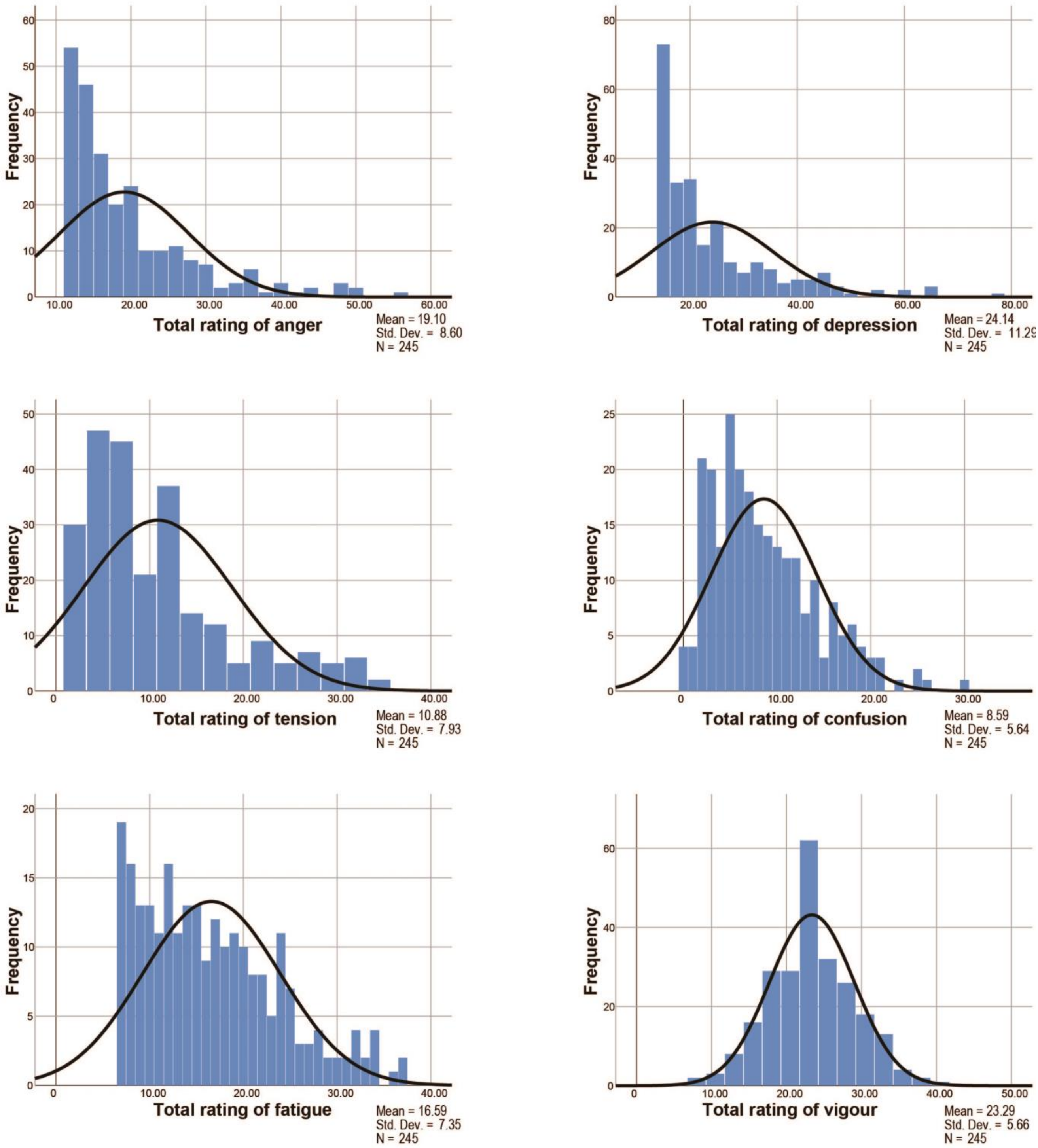

Figure 4.5 frequency against total mood score rating histograms of six mood states.

Figure 4.5 shows that along with the vigour group, data from five other mood states groups have different degrees of skewness and kurtosis. Due to this non-normally distribution non parametric tests were implemented for data analysis.

The Mann–Whitney test (non-parametric tests for categorised variables) and Spearman's correlation coefficient (non-parametric test for data that is measured in interval, i.e. temperature) were applied because of the uneven participant group sizes and non-normally distributed data. Finally, multiple regression analysis was conducted to study the interrelation between independent variables. Of the 249 surveys gathered, 4 outliers were removed because of extremely high mood disturbance scores, and judgement was based on whether or not an individual's scores of any mood state was three times greater than that of the interquartile range from either end of the data set set (the outlier analysis was done using SPSS statistical software). In total, 245 participants were chosen, as the prior power calculation showed (section 4.2.4) that a total of 226 participants is sufficient to achieve a power of 80% for a medium effect size [d = 0.5], hence 245 participants were sufficient.

Independent variables (factors) were categorised by referencing Mehrabian and Russell's single stimulus dimensions: colour; heat; light; and sound (Mehrabian & Russell, 1974). Based on this study, the three environmental categories selected were: light conditions; thermal conditions; and sounds. Environmental factors were judged and recorded as text by the surveyor, based on related visuals, sounds, or activities that were present on-site during each survey session. The presence/absence of sunlight was judged by whether the sun was blocked by clouds during the survey or preceding the observation period. The temperature reading was taken from both weather stations (Manchester Airport, United Kingdom)(Time and date, nd) and a traditional hand-held alcohol thermometer for each survey. Finally, the presence/absence of a sound type was identified depending on whether it was audible when the surveyor focused on listening at the location. The sound types recorded during the surveys were categorised prior to data analysis, based on the related activity of each sound (Brown, Kang & Gjestland, 2011). Sound taxonomy was implemented to examine independent sound variables in detail, which were identified as street performance (vocal and instrumental), music from adjacent shops, traffic, machinery (i.e. amusement rides), water fountains, birdsong, children's sounds, an ice-cream van, and street vendors (see Figure 4.6).

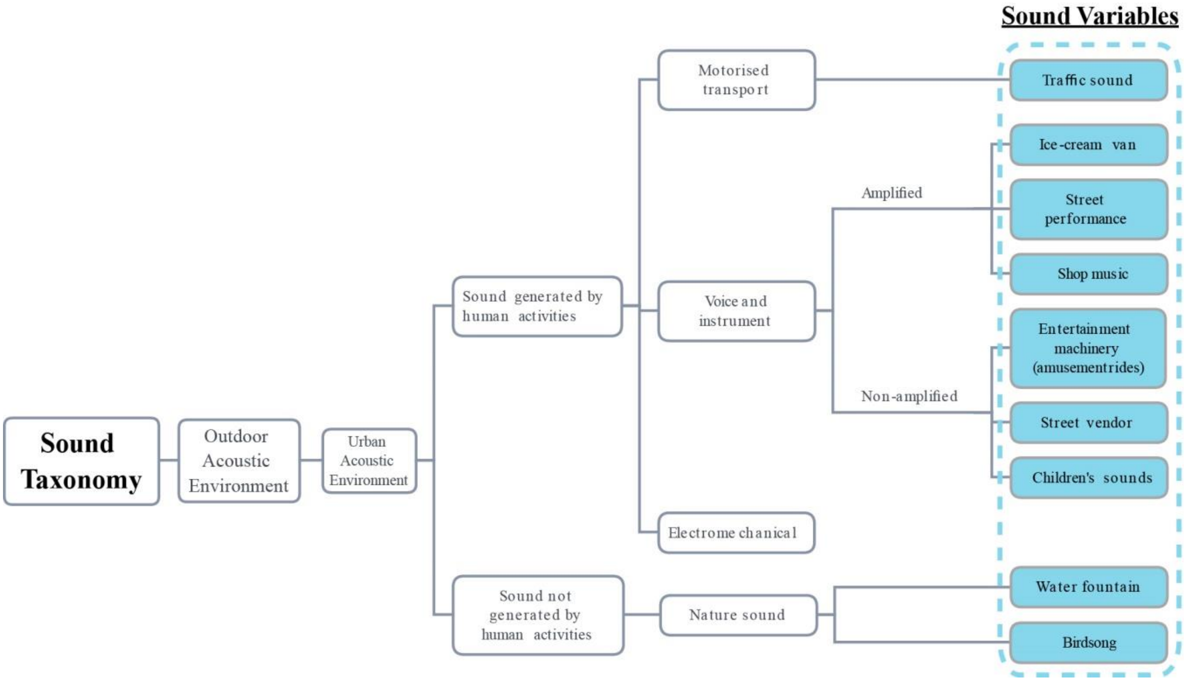

Figure 4.6 Sound taxonomy based on Brown et al.'s study (2011)

Dependent variables included anger, confusion, depression, fatigue, tension, vigour, and Total Mood Disturbance (TMD). Each dependent variable was calculated by adding scores from the words in that category, except TMD, which was calculated by adding scores from negative words and subtracting scores from positive words. The scores ranged from -12 to 278.

All analyses were performed using IBM SPSS. Figure 4.7 shows the process of variable analysis through a statistical model (temperature, as an exception, was analysed via Spearman correlation).

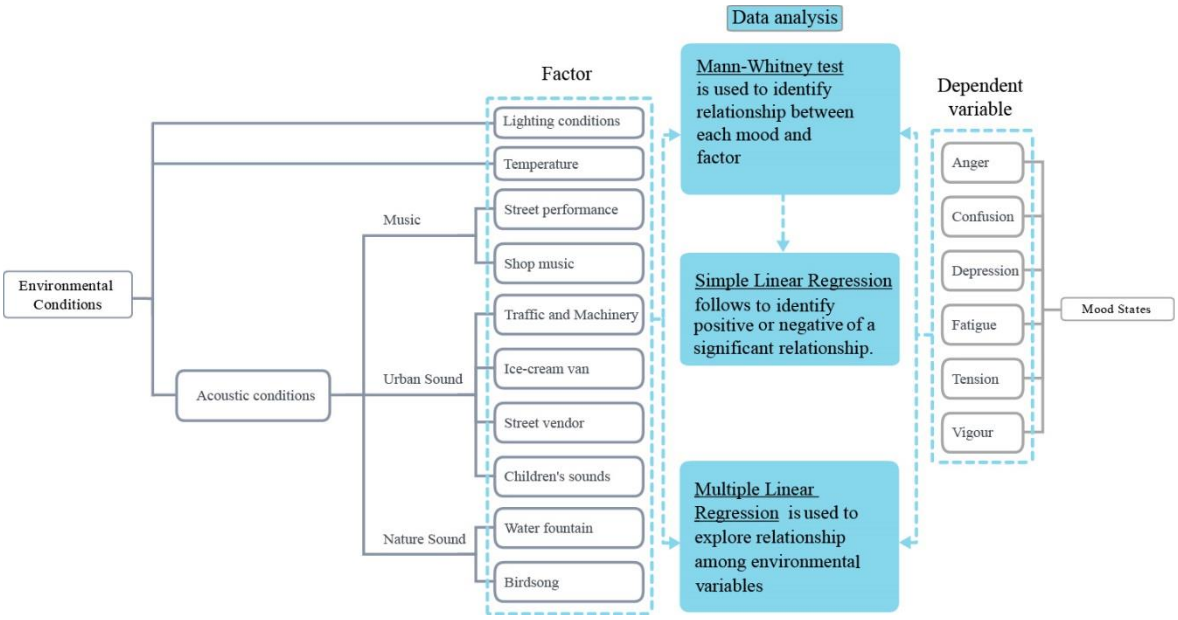

Figure 4.7 How statistical models were used to analyse the gathered data

The results will also be discussed through the lens of appraisal theory. Appraisal theory views each distinct emotion as groups of environmental appraisal components, and these components form a distinct appraisal pattern that can accurately represent an emotion. The theory focuses on the understanding of the person-environment relationship and the core relational theme that summarise the uniqueness of each distinct emotion. Analysing the results from the statistical models through the lens of appraisal theory provides insight into why and how such emotional response comes to be. This is crucial to a study of soundscape and emotions.

4.3 Results

This section is structured to answer the following study research question 1: ‘How does the soundscape of urban public space affect mood or emotions?’ (see also section 1.2.1), with discussions regarding the results included in the corresponding sub-sections.

4.3.1 Effect of environmental conditions on mood states

4.3.1.1 Weather condition

The descriptive statistics relating to the survey results of weather conditions are shown in Tables 4.1 a and 4.1 b below:

Cloudy Weather		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		45	45	45	45	45	45
Mean		19.09	9.29	25.48	18.07	12.71	23.14
Median		16.00	8.00	22.00	16.50	11.00	24.00
Range		36.00	19.00	46.00	30.00	31.00	23.00
Minimum		12.00	2.00	15.00	7.00	2.00	9.00
Maximum		48.00	21.00	61.00	37.00	33.00	32.00
Percentiles	25	13.50	5.00	17.00	10.00	5.50	18.50
	50	16.00	8.00	22.00	16.50	11.00	24.00
	75	25.00	13.50	29.00	24.00	16.00	27.50
Std. Error of Mean		1.17	0.80	1.65	1.18	1.35	0.88
Std. Deviation		7.86	5.38	11.05	7.91	9.05	5.89
Variance		61.81	28.94	122.02	62.60	81.85	34.75
Skewness		1.58	0.49	1.56	0.60	0.96	-0.51
Std. Error of Skewness		0.35	0.35	0.35	0.35	0.35	0.35
Kurtosis		2.82	-0.80	2.26	-0.35	-0.21	-0.30
Std. Error of Kurtosis		0.69	0.69	0.69	0.69	0.69	0.69

Table 4.1 a displaying descriptive statistics details for the cloudy weather group

Sunny Weather		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		199	199	199	199	199	199
Mean		19.05	8.45	23.80	16.23	10.45	23.48
Median		16.00	7.00	19.00	15.00	8.00	23.00
Range		43.00	30.00	62.00	29.00	33.00	33.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		55.00	30.00	77.00	36.00	35.00	41.00
Percentiles	25	13.00	4.00	16.00	10.50	5.00	20.00
	50	16.00	7.00	19.00	15.00	8.00	23.00
	75	22.00	12.00	28.00	20.00	14.00	27.00
Std. Error of Mean		0.62	0.40	0.81	0.51	0.54	0.40
Std. Deviation		8.76	5.70	11.37	7.21	7.63	5.61
Variance		76.77	32.54	129.23	51.92	58.23	31.42
Skewness		1.80	1.01	1.92	0.72	1.29	0.31
Std. Error of Skewness		0.17	0.17	0.17	0.17	0.17	0.17
Kurtosis		3.08	0.93	4.08	-0.15	1.12	0.19
Std. Error of Kurtosis		0.34	0.34	0.34	0.34	0.34	0.34

Table 4.1 b displaying descriptive statistics details of the sunny weather group

As shown in Table 4.1 a and b, the participant size of the two weather groups differed significantly, and neither group's skewness and kurtosis value was close to 0. This indicates the data set was not normally distributed, hence non-parametric test (Mann-Whitney test) was used to examine the effect of weather difference on individual mood states. Table 4.2 shows the Mann–Whitney test results. No mood category was significantly different between sunny and cloudy weather conditions [p >.05, ns].

Table 4.2 Mann–Whitney test of mood states related to lighting conditions

Variable	Emotion Category	Group	Median	p-value (2-tailed)	Mann–Whitney Test (U)	Z-value	Effect Size (r)
Weather	Anger	Sunny Cloudy	16.00 16.00	0.583 (ns)	4244.50	-0.55	-0.04
	Confusion	Sunny Cloudy	7.00 8.00	0.262 (ns)	3998.50	-1.12	-0.07
	Depression	Sunny Cloudy	19.00 22.00	0.097 (ns)	3771.00	-1.66	-0.11
	Fatigue	Sunny Cloudy	15.00 16.00	0.145 (ns)	3855.00	-1.46	-0.09
	Tension	Sunny Cloudy	8.00 11.00	0.133 (ns)	3835.50	-1.51	-0.10
	Vigour	Sunny Cloudy	23.00 24.00	0.851 (ns)	4397.50	-0.19	-0.01
	Total Mood Disturbance (TMD)	Sunny Cloudy	44.00 54.00	0.126 (ns)	3823.00	-1.53	-0.10

Significance: p<0.05; small effect: r=0.10; medium effect r=0.20; large effect r=0.5

Simple regression was conducted to identify the intensity and direction (for identifying one-tailed results) of the effect; no significant relationship was found between daylight conditions (cloudy or sunny) and depressed mood [R=.058, R^2=.003, B=-1.674, p>.05, ns]. The results suggest that light conditions produced by sunny or cloudy weather cannot reliably predict depressed mood, contradicting Mehrabian and Russell (1974) who reported that brightness and saturation had a direct correlation with pleasantness. There are three possible explanations. First, Mehrabian and Russell's study only considered light conditions in relation to colour (saturation and brightness) but not the effect in real environmental contexts. Second, pleasantness is a relatively vague mood. When considered through appraisal theory, the closest match is the happiness/joy emotion. However, as the appraisal pattern of happiness suggests, the only two defining components are goal relevance and goal congruence, which are included in all positive emotions. Therefore, pleasantness as a mood category could include multiple positive mood categories; the present study's questionnaire only included one positive mood category, *vigorous*, and POMS was mostly used to examine negative moods. Third, the change in light conditions caused by sunny/cloudy weather was minor, and limiting lighting conditions to only 'sunny' or 'cloudy' might not have been sufficient.

4.3.1.2 Temperature

The descriptive statistic of the survey results related to temperature is shown below (see Table 4.3. The temperature was measured at the interval; the table is also a result of non-grouped data).

		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		245	245	245	245	245	245
Mean		19.10	8.59	24.14	16.59	10.88	23.39
Std. Error of Mean		0.55	0.36	0.72	0.47	0.51	0.36
Median		16.00	7.00	20.00	15.00	9.00	23.00
Std. Deviation		8.60	5.64	11.29	7.35	7.92	5.66
Variance		73.93	31.76	127.55	54.05	62.80	32.00
Skewness		1.74	0.92	1.83	0.70	1.22	0.14
Std. Error of Skewness		0.16	0.16	0.16	0.16	0.16	0.16
Kurtosis		2.94	0.62	3.62	-0.20	0.80	0.08
Std. Error of Kurtosis		0.31	0.31	0.31	0.31	0.31	0.31
Range		43.00	30.00	62.00	30.00	33.00	33.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		55.00	30.00	77.00	37.00	35.00	41.00
Percentiles	25	13.00	4.00	16.00	10.25	5.00	20.00
	50	16.00	7.00	20.00	15.00	9.00	23.00
	75	22.00	12.00	28.00	21.00	14.00	27.00

Table 4.3 displaying the descriptive statistics for the survey results (for temperature groups)

Table 4.3 shows that the skewness and kurtosis values were not close 0, which indicates a data set that was not normally distributed (for a graphical analysis see also Figure 4.5). Hence, a non-parametrical statistical test (Spearman's correlation) was implemented. Table 4.4 shows that there was no significant relationship between air temperature and the six mood categories [p>.05, ns].

Table 4.4 Spearman's test for emotional response related to air temperature

Variables	Emotion Category	Spearman's Correlation (r)	p-value (2-tailed)
Temperature	Anger	-0.11	0.088
	Confusion	-0.68	0.289
	Depression	-0.08	0.236
	Fatigue	-0.06	0.388
	Tension	-0.10	0.126
	Vigour	0.09	0.152
	Total Mood Disturbance (TMD)	-0.09	0.142

Significance: p<0.05

Mehrabian and Russell (1974) concluded that the further ambient temperature deviated from body temperature, the more emotional arousal there is, suggesting that temperatures between 15.5^{o}C and 20^{o}C were optimal for thermal comfort. With 75% of the present study's participants' data collection period falling between 14 ℃ and 24 ℃, the air temperature may not have shifted sufficiently to trigger significant emotional arousal. Furthermore, if a thermal condition is produced naturally and/or matches people's expectations, they are more tolerant of it (Nikolopoulou & Steemers, 2003). Both these conditions were met in the present study.

Relative humidity and air temperature data were retrieved from the weather station (Manchester airport) and dew point temperature calculated based on Equation 1 (see Figure 4.8).

$$T_d = \frac{[b\alpha(T,RH)]}{[a - \alpha(T,RH)]}$$

Equation 1 dew point temperature calculation

T_d is dew point temperature in °C; T is air temperature in °C; RH is relative humidity in %; a and b are coefficients for Sonntag 90 constant set where a = 17.62 and b = 243.12℃;

$\alpha(T, RH) = \ln\left(\frac{RH}{100}\right) + \frac{aT}{b+T}$

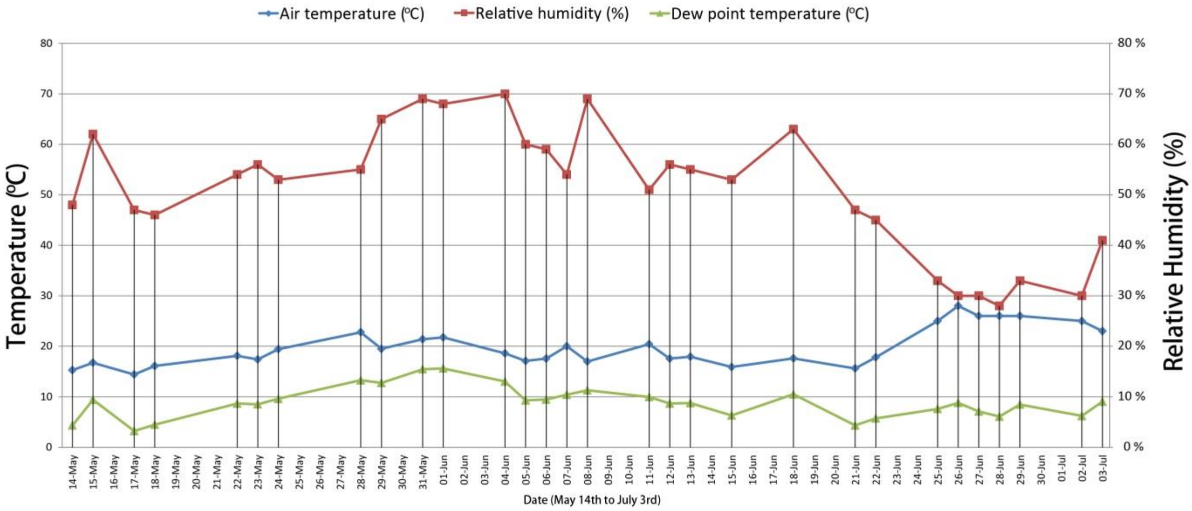

Figure 4.8 Average daily air temperature, relative humidity and dew point temperatures between 14th of May and 3rd July

As shown in Figure 4.7, across the survey period, the range of air temperature was 14-24℃, the range of humidity was 28-78% and the dew point temperature was 4-16℃. Based on the occupational safety and health administration (OSHA) technical manual (OSHA Technical Manual, n.d.) air temperature in the range of 68-76°F (20-24.5°C) and relative humidity range of 20-60% is considered comfortable. Based on the calculation of dew point temperature this is within a range of 4-16.5℃. The dew point temperature range in the current survey study was in range of this temperature. This provides a further explanation in the non-significant effect of temperature on emotional response, since the variation within the comfortable temperature range may not produce enough changes to elicit an implicit or explicit emotional response.

An assumption could thus be made that air temperature does not have a significant correlation with mood state; instead, the relation between mood state and thermal comfort may come from the experience of a change in thermal conditions. Further study on this assumption is required.

There may also have been some deviation in the temperature recording. First, only the air temperature was recorded; this did not represent the apparent temperature which is also influenced by humidity and wind, factors that were not recorded during the survey process. Second, the temperature data were pulled from the local weather station, and there may have been potential differences and delays in data between the site and the station. However, these deviations should not have had a significant influence on the results as the overall weather conditions were relatively stable, and no significant change occurred during the data collection period.

4.3.2 Effect of music on mood states

4.3.2.1 Street music (popular music)

The descriptive statistics of the street music groups, and non-street music group are shown in Tables 4.5 a and 4.5 b. The skewness and kurtosis were not close to the value of 0 indicating the grouped data were not normally distributed. Additionally, the participant sizes differed significantly between the music group and non-music group, hence a non-parametric statistical model (Mann–Whitney test) was implemented.

With street music		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		202	202	202	202	202	202
Mean		19.41	9.22	25.04	17.43	11.53	23.22
Std. Error of Mean		0.60	0.40	0.83	0.52	0.58	0.40
Median		17.00	8.00	21.00	16.75	10.00	23.00
Std. Deviation		8.52	5.63	11.82	7.44	8.20	5.64
Variance		72.53	31.72	139.79	55.28	67.23	31.86
Skewness		1.70	0.78	1.71	0.55	1.11	0.21
Std. Error of Skewness		0.17	0.17	0.17	0.17	0.17	0.17
Kurtosis		3.01	0.43	3.05	-0.38	0.47	0.27
Std. Error of Kurtosis		0.34	0.34	0.34	0.34	0.34	0.34
Range		43.00	30.00	62.00	30.00	33.00	33.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		55.00	30.00	77.00	37.00	35.00	41.00
Percentiles	25	13.00	5.00	16.00	11.00	5.00	20.00
	50	17.00	8.00	21.00	16.75	10.00	23.00
	75	23.25	12.25	29.25	22.25	15.00	26.63

Table 4.5 a displaying the descriptive statistics for the street music group

Without street music		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		43	43	43	43	43	43
Mean		17.63	5.65	19.93	12.65	7.79	24.17
Std. Error of Mean		1.36	0.72	1.08	0.84	0.85	0.87
Median		14.00	5.00	17.00	12.00	6.00	25.00
Std. Deviation		8.93	4.69	7.07	5.49	5.60	5.72
Variance		79.72	21.99	49.92	30.18	31.31	32.71
Skewness		2.12	2.23	2.13	1.70	1.74	-0.16
Std. Error of Skewness		0.36	0.36	0.36	0.36	0.36	0.36
Kurtosis		3.70	6.39	4.26	3.77	2.87	-0.49
Std. Error of Kurtosis		0.71	0.71	0.71	0.71	0.71	0.71
Range		35.00	24.00	29.00	25.00	23.00	23.00
Minimum		12.00	1.00	15.00	7.00	2.00	11.00
Maximum		47.00	25.00	44.00	32.00	25.00	34.00
Percentiles	25	12.00	2.00	15.00	8.00	4.00	20.00
	50	14.00	5.00	17.00	12.00	6.00	25.00
	75	18.00	7.00	21.00	14.00	10.00	29.00

Table 4.5 b showing the descriptive statistics for the group without street music presence

Table 4.6 illustrates the Mann–Whitney test results, where anger, confusion, depression, fatigue, tension, and TMD scores were significantly different according to the presence or absence of the street performance [$p<.05$]. Only the vigour category showed no significant difference in this regard [$p>.05$].

Table 4.6 Mann–Whitney test of mood states categories related to street performance (popular music)

	Emotion Category	Group	Median	p-value (2-tailed)	Mann–Whitney Test (U)	Z-value	Effect Size (r)
Street Performance (popular music)	Anger	Yes No	14.00 17.00	0.032 (sig)	3448.00	-2.14	-0.14
	Confusion	Yes No	5.00 8.00	<0.001 (sig)	2493.50	-4.39	-0.28
	Depression	Yes No	17.00 21.00	0.006 (sig)	3186.00	-2.76	-0.18
	Fatigue	Yes No	12.00 16.75	<0.001 (sig)	2606.00	-3.12	-0.20
	Tension	Yes No	6.00 10.00	0.003 (sig)	33133.50	-2.92	-0.19
	Vigour	Yes No	25.00 23.00	0.354 (ns)	3861.00	-1.14	-0.07
	Total Mood Disturbance (TMD)	Yes No	31.00 51.00	<0.001 (sig)	2721.50	-3.84	-0.25

Significance: p<0.05; small effect: r=0.10; medium effect r=0.20; large effect r=0.5

A further simple regression was conducted to test the intensity and direction of this effect. The mood categories of confusion [R=.241, R^2=.006, B= -3.567, p<.05, sig], depression [R=.173, R^2=.030, B=-5.112, p<.05, sig], fatigue [R=.248, R^2=.061, B=-4.777, p<.05, sig], tension [R=.180, R^2=.032, B=-3.741, p<.05, sig], and TMD [R=.204, R^2=.042, B=-19.932, p<.05, sig] had significant negative relationships with street performance. The presence of street music explained variance in the mood scores by 5.8% for confusion, 3.0% for depression, 6.1% for fatigue, 3.2% for tension, and 4.2% for TMD. The simple regression also showed that anger could not be reliably predicted by street performance [p>.05, ns], even though the mean score showed a significant difference in the Mann–Whitney test, suggesting that this difference was driven by other factors.

The results were consistent with Axelsson's soundscape perception model, which reported that street performance, as part of a soundscape, could be considered eventful and pleasant (Axelsson et al., 2010). Street performance is different from other sound sources in an urban soundscape, in that when present, it usually attracts attention and takes a dominant position over other acoustical stimuli. Soundscapes with dominant human sounds are also considered more eventful than soundscapes without (Viollon & Lavandier, 2000).

4.3.2.2 Shop music

Music originating from a shop adjacent to the public space was present during some of the survey sessions, although it was faint and did not take a dominant position in the sound environment. The Tables 4.7 a and 4.7 b display the descriptive statistics of the shop music group and non-shop music group. As shown, the skewness and the kurtosis value is far from the value 0 indicating the data has violated the normality assumption in the statistics. Additionally, participant size between the two groups were largely different, hence non-parametric test (Mann–Whitney test) were implemented.

with shop music		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		22	22	22	22	22	22
Mean		22.18	10.68	27.41	17.59	14.27	23.27
Std. Error of Mean		2.01	1.24	2.23	1.33	1.83	0.84
Median		20.50	11.00	26.00	18.00	12.50	23.50
Std. Deviation		9.42	5.79	10.47	6.22	8.58	3.94
Variance		88.82	33.56	109.68	38.63	73.54	15.54
Skewness		0.63	0.16	0.37	0.82	0.57	0.05
Std. Error of Skewness		0.49	0.49	0.49	0.49	0.49	0.49
Kurtosis		-0.63	-0.82	-1.30	1.12	-0.69	-0.09
Std. Error of Kurtosis		0.95	0.95	0.95	0.95	0.95	0.95
Range		30.00	19.00	30.00	27.00	29.00	15.00
Minimum		12.00	2.00	15.00	7.00	3.00	16.00
Maximum		42.00	21.00	45.00	34.00	32.00	31.00
Percentiles	25	12.75	5.00	17.75	12.75	7.00	20.75
	50	20.50	11.00	26.00	18.00	12.50	23.50
	75	29.50	14.50	38.25	20.25	21.00	25.25

Table 4.7 a displaying the descriptive statistics for the group with shop music

without shop music		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		223	223	223	223	223	223
Mean		18.79	8.39	23.82	16.49	10.54	23.40
Std. Error of Mean		0.57	0.37	0.76	0.50	0.52	0.39
Median		16.00	7.00	19.00	15.00	8.00	23.00
Std. Deviation		8.47	5.59	11.34	7.46	7.80	5.81
Variance		71.82	31.26	128.65	55.64	60.81	33.70
Skewness		1.90	1.01	1.97	0.70	1.32	0.14
Std. Error of Skewness		0.16	0.16	0.16	0.16	0.16	0.16
Kurtosis		3.68	0.93	4.20	-0.25	1.13	0.00
Std. Error of Kurtosis		0.32	0.32	0.32	0.32	0.32	0.32
Range		43.00	30.00	62.00	30.00	33.00	33.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		55.00	30.00	77.00	37.00	35.00	41.00
Percentiles	25	13.00	4.00	16.00	10.00	5.00	19.50
	50	16.00	7.00	19.00	15.00	8.00	23.00
	75	21.00	12.00	27.00	22.00	13.00	27.00

Table 4.7 b displaying descriptive statistics for the group without shop music

Table 4.8 Mann-Whitney test of mood state categories related to Shop music

	Emotion Categories	Groups	Median	p-Value (2-tailed)	Mann-Whitney test (U)	Z value	Effective Size (r)
Shop music	Anger	Yes	20.50	0.105 (ns)	1942.00	-1.62	-0.10
		No	16.00				
	Confusion	Yes	11.00	0.057 (ns)	1850.00	-1.90	-0.12
		No	7.00				
	Depression	Yes	26.00	0.069 (ns)	1880.00	-1.82	-0.12
		No	19.00				
	Fatigue	Yes	18.00	0.307 (ns)	2128.00	-1.03	-0.07
		No	15.00				
	Tension	Yes	12.50	0.027 (sig)	1757.00	-2.20	-0.14
		No	8.00				
	Vigour	Yes	23.50	0.984 (ns)	2446.50	-0.02	0.00
		No	23.00				
	Total Mood Disturbance (TMD)	Yes	61.50	0.05 (sig)	1833.00	-1.96	-0.12
		No	44.00				

Significance: p<0.05; small effect: r=0.10; medium effect r=0.20; large effect r=0.5

The Mann–Whitney results showed that shop music had small effects on tension [p<.05, sig., $Mdn_{presence}$=12.50, $Mdn_{not\text{-}presence}$=8.00, U=1757.00, Z=-2.20, r=-0.14] and TMD [p<.05, sig., $Mdn_{presence}$=61.50, $Mdn_{not\text{-}presence}$=44.00, U=1833.00, Z=-1.96, r=-0.12]. Furthermore, confusion [$p=.057$] and depression [$p=.069$] had two-tailed results that could have been significant one-tailed results. Further analysis is therefore required (see Table 4.8).

Simple regression was conducted to further examine the mood categories of confusion, depression, tension, and TMD. The results showed that the mood score for tension had a significant positive relationship with the presence of shop music [$R=.135$, $R^2=.018$, $B=3.732$, $p<.05$, sig]. Although the simple regression model predicted tense mood well, it only explained 1.8% of the variance in the tension score. The analysis showed there were no significant relationships between shop music and confusion, depression, or TMD.

Shop music and street music had opposite effects on participants: the presence of street performance produced an overall reduction in negative mood scores, whereas the presence of shop music produced an increase in a negative mood scores. This trend appeared in mood categories that showed significant results (i.e. tension) and non-significant results (i.e. confusion, depression, and tension). These seemingly contradictory results could have resulted from several aspects that differed between the two music-related variables.

First, the context behind the two music variables was different. On the one hand, street music is played live and is often entertaining, joyful, and pleasant. On the other hand, shop music is replayed through media sources and is a part of a commercial business. The environmental settings of public space versus shop environment also differ, which may induce differences when people are interpreting their moods, based on Robinson's idea that people interpreted unknown emotions by drawing context from the surrounding environment (Robinson, 2005b). This assumption was further supported by Nikolopoulou's study showing that people's responses to physical stimulation were based on the contextual information that it contained (Nikolopoulou & Steemers, 2003).

Second, the street music took a dominant position within its sound environment, whereas the shop music did not. Based on the components model of sound perception, this difference in dominance separated the two music sources into eventful and uneventful sounds (Axelsson et al., 2010). The street music could be considered eventful and pleasant, hence the reduction in negative mood scores. However, the shop music could be considered uneventful and unpleasant, hence the increase in negative mood scores. These positions of dominance within the sound environment may also explain why the shop music had a less significant effect on mood state outcomes.

4.3.3 Effect of urban sounds on mood states

4.3.3.1 Traffic and machinery

The descriptive statistics for traffic and machine groups are shown in Tables 4.9 a, 4.9 b, 4.9 c and 4.9 d. The tables show the skewness and kurtosis values are not close to 0 indicating data from neither group are normally distributed. Together with the large difference in sample sizes, a non-parametric statistical test (Mann–Whitney test) was implemented.

With Traffic		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		197	197	197	197	197	197
Mean		19.22	8.90	24.67	16.94	11.13	23.39
Std. Error of Mean		0.63	0.42	0.85	0.54	0.59	0.41
Median		16.00	8.00	20.00	16.00	9.00	23.00
Std. Deviation		8.81	5.87	11.93	7.53	8.28	5.71
Variance		77.55	34.47	142.27	56.76	68.54	32.65
Skewness		1.71	0.88	1.76	0.63	1.16	0.18
Std. Error of Skewness		0.17	0.17	0.17	0.17	0.17	0.17
Kurtosis		2.76	0.47	3.19	-0.30	0.55	0.21
Std. Error of Kurtosis		0.34	0.34	0.34	0.34	0.34	0.34
Range		43.00	30.00	62.00	30.00	33.00	33.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		55.00	30.00	77.00	37.00	35.00	41.00
Percentiles	25	13.00	4.50	16.00	10.00	5.00	20.00
	50	16.00	8.00	20.00	16.00	9.00	23.00
	75	22.00	12.00	28.50	22.00	14.50	27.00

Table 4.9 a Showing descriptive statistics for the traffic group

Without Traffic		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		48	48	48	48	48	48
Mean		18.58	7.31	21.98	15.15	9.81	23.38
Std. Error of Mean		1.12	0.63	1.14	0.93	0.90	0.79
Median		15.00	6.00	19.00	14.00	8.00	24.00
Std. Deviation		7.75	4.37	7.93	6.42	6.23	5.47
Variance		60.08	19.07	62.91	41.23	38.79	29.97
Skewness		1.93	0.71	1.43	0.95	1.37	0.00
Std. Error of Skewness		0.34	0.34	0.34	0.34	0.34	0.34
Kurtosis		4.23	-0.44	1.06	0.35	1.61	-0.53
Std. Error of Kurtosis		0.67	0.67	0.67	0.67	0.67	0.67
Range		35.00	15.00	29.00	26.00	26.00	23.00
Minimum		12.00	2.00	15.00	7.00	2.00	11.00
Maximum		47.00	17.00	44.00	33.00	28.00	34.00
Percentiles	25	13.00	4.00	16.00	11.00	5.00	19.00
	50	15.00	6.00	19.00	14.00	8.00	24.00
	75	22.75	10.00	24.50	18.00	12.00	27.75

Table 4.9 b Showing descriptive statistics for the non-traffic group

With machines		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		55	55	55	55	55	55
Mean		18.85	7.85	22.89	15.33	10.35	23.30
Std. Error of Mean		1.07	0.71	1.34	0.92	0.92	0.76
Median		15.00	6.00	19.00	14.00	9.00	24.00
Std. Deviation		7.93	5.26	9.92	6.85	6.84	5.65
Variance		62.83	27.65	98.40	46.89	46.79	31.87
Skewness		1.70	1.07	1.80	0.93	1.42	0.05
Std. Error of Skewness		0.32	0.32	0.32	0.32	0.32	0.32
Kurtosis		2.98	0.52	3.27	0.08	1.56	-0.74
Std. Error of Kurtosis		0.63	0.63	0.63	0.63	0.63	0.63
Range		35.00	21.00	46.00	26.00	29.00	23.00
Minimum		12.00	2.00	15.00	7.00	2.00	11.00
Maximum		47.00	23.00	61.00	33.00	31.00	34.00
Percentiles	25	13.00	4.00	16.00	10.00	5.00	19.00
	50	15.00	6.00	19.00	14.00	9.00	24.00
	75	24.00	11.00	26.00	19.00	12.00	28.00

Table 4.9 c displaying descriptive statistics for the machine group

Without machines		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		190	190	190	190	190	190
Mean		19.17	8.81	24.51	16.96	11.03	23.42
Std. Error of Mean		0.64	0.42	0.85	0.54	0.60	0.41
Median		16.00	8.00	20.00	16.00	8.50	23.00
Std. Deviation		8.80	5.74	11.66	7.47	8.22	5.68
Variance		77.47	32.90	135.96	55.78	67.61	32.21
Skewness		1.75	0.88	1.81	0.64	1.17	0.17
Std. Error of Skewness		0.18	0.18	0.18	0.18	0.18	0.18
Kurtosis		2.94	0.65	3.56	-0.24	0.62	0.32
Std. Error of Kurtosis		0.35	0.35	0.35	0.35	0.35	0.35
Range		43.00	30.00	62.00	30.00	33.00	33.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		55.00	30.00	77.00	37.00	35.00	41.00
Percentiles	25	13.00	4.75	16.00	10.38	5.00	20.00
	50	16.00	8.00	20.00	16.00	8.50	23.00
	75	22.00	12.00	28.00	22.00	14.25	27.00

Without machines		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		190	190	190	190	190	190
Mean		19.17	8.81	24.51	16.96	11.03	23.42
Std. Error of Mean		0.64	0.42	0.85	0.54	0.60	0.41
Median		16.00	8.00	20.00	16.00	8.50	23.00
Std. Deviation		8.80	5.74	11.66	7.47	8.22	5.68
Variance		77.47	32.90	135.96	55.78	67.61	32.21
Skewness		1.75	0.88	1.81	0.64	1.17	0.17
Std. Error of Skewness		0.18	0.18	0.18	0.18	0.18	0.18
Kurtosis		2.94	0.65	3.56	-0.24	0.62	0.32
Std. Error of Kurtosis		0.35	0.35	0.35	0.35	0.35	0.35
Range		43.00	30.00	62.00	30.00	33.00	33.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		55.00	30.00	77.00	37.00	35.00	41.00
Percentiles	25	13.00	4.75	16.00	10.38	5.00	20.00
	50	16.00	8.00	20.00	16.00	8.50	23.00
	75	22.00	12.00	28.00	22.00	14.25	27.00

Table 4.9 d displaying descriptive statistics details for the non-machine group

The Mann–Whitney tests showed no significant relationship between any mood category and traffic or amusement ride noise [p>.05, ns], indicating that neither the sound nor visual aspects of traffic or amusement ride had a significant effect on mood states (see Tables 4.10 and Table 4.11).

Table 4.10 Mann-Whitney test of mood state categories related to Traffic

	Emotion Categories	Groups	Median	p-Value (2-tailed)	Mann-Whitney test (U)	Z value	Effective Size (r)
Traffic	Anger	Yes	16.00	0.945 (ns)	4697.50	-0.07	-0.004
		No	15.00				
	Confusion	Yes	8.00	0.134 (ns)	4069.50	-1.50	-0.096
		No	6.00				
	Depression	Yes	20.00	0.526 (ns)	4449.50	-0.64	-0.041
		No	19.00				
	Fatigue	Yes	16.00	0.170 (ns)	4123.00	-1.38	-0.088
		No	14.00				
	Tension	Yes	9.00	0.728 (ns)	4574.50	-0.35	-0.022
		No	8.00				
	Vigour	Yes	23.00	0.939 (ns)	4694.00	-0.08	-0.005
		No	24.00				
	Total Mood Disturbance (TMD)	Yes	48.00	0.404 (ns)	4359.50	-0.84	-0.053
		No	41.50				

Table 4.11 Mann-Whitney test of mood state categories related to Entertainment Machinery

	Emotion Categories	Groups	Median	p Value (2-tailed)	Mann-Whitney test (U)	Z value	Effective Size (r)
Entertainment Machinery	Anger	Yes	15.00	0.845 (ns)	5134.50	-0.20	-0.013
		No	16.00				
	Confusion	Yes	6.00	0.246 (ns)	4688.50	-1.16	-0.074
		No	8.00				
	Depression	Yes	19.00	0.569 (ns)	4961.50	-0.57	-0.037
		No	20.00				
	Fatigue	Yes	14.00	0.152 (ns)	4561.50	-1.44	-0.092
		No	16.00				
	Tension	Yes	9.00	0.969 (ns)	5206.50	-0.04	-0.003
		No	8.50				
	Vigour	Yes	24.00	0.936 (ns)	5187.50	-0.08	-0.005
		No	23.00				
	Total Mood Disturbance (TMD)	Yes	40.00	0.485 (ns)	490.50	-0.70	-0.045
		No	48.50				

Significance: $p<0.05$; small effect: $r=0.10$; medium effect $r=0.20$; large effect $r=0.5$

This result differed from previous soundscape studies reporting that mechanical and industrial sounds were universally associated with negative emotions (Moscoso, Peck & Eldridge, 2018). Further, in the sound masking field, some studies have observed the ability of natural sound to mask the annoyance caused by traffic noise (Hao et al., 2016; Jeon et al., 2010). The present result might have been affected by the urban setting of the survey, as people living in the city may have a more emotional affinity towards an urban environment than other groups, which could potentially reduce the negative effect on their mood states. In Moscoso et al. (2018), three community groups—living respectively in a rural, forested area, a suburban area, and an urban area—were asked to name three sounds from their hometowns that fell into each of the following five emotional categories: happiness; sadness; tranquillity; fear; and irritation. The results showed that most people had a positive emotional response to nature sounds, but that within the forest group, the emotional response was more diverse compared to the other two groups (Moscoso et al., 2018). Moscoso et al. concluded that the forest group had a more emotional affinity with the natural environment since the nature sound was considered uneventful. The tranquillity effect of nature was weakened within this group, who, instead, had a much more sensitive response toward other aspects of the nature sounds that were ignored by the other groups. The results of Moscoso et al. (2018) indicated that people who lived in different environments tended to respond differently to acoustic environments.

This difference in sound perceptions between different social groups was also supported by Axelsson's soundscape perception model, which described monotonous sounds as unpleasant and uneventful (Axelsson et al., 2010). Applying the same idea to the urban setting, where traffic and amusement ride sounds were perceived as routine, the mood state response to these sounds would be less negative within an urban environment. Similarly, Axelsson (2015) suggested that the appropriateness of a soundscape could be a potential third dimension alongside eventfulness and pleasantness for perceived affective soundscape quality (Axelsson et al., 2010). Van den Bosch et al. (2018) proposed that a positive emotional response could be achieved when a real-world situation matched cognitive schemes (e.g. expecting a certain sound in a certain environment) (van den Bosch et al., 2018). In this case, it was reasonable to assume that traffic sounds may be expected in an urban setting, and the result suggested that an appropriate sound type in its expected location may reduce the mood arousal derived from such a sound. However, this assumption lacks experimental support, and further study is required. Additionally, negativity from amusement ride sounds may have been neutralised by the entertainment value of the amusement rides, a hypothesis that also requires further study.

4.3.3.2 Ice-cream van

The descriptive statistics of the ice-cream van groups are shown in Tables 4.12 a and 4.12 b. The skewness and kurtosis values are not close to 0, indicating that the data set was not normally distributed. Hence, a non-parametric statistical test (Mann–Whitney test) was used due to the violation of the normality assumption.

With ice-cream van		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		99	99	99	99	99	99
Mean		17.88	7.03	21.87	15.56	8.94	24.26
Std. Error of Mean		0.77	0.50	0.93	0.72	0.63	0.62
Median		15.00	6.00	18.00	14.00	7.00	24.00
Std. Deviation		7.70	4.95	9.30	7.15	6.25	6.15
Variance		59.35	24.46	86.42	51.11	39.00	37.83
Skewness		2.08	1.07	1.92	0.80	1.30	-0.05
Std. Error of Skewness		0.24	0.24	0.24	0.24	0.24	0.24
Kurtosis		5.38	0.84	3.72	-0.03	1.69	-0.26
Std. Error of Kurtosis		0.48	0.48	0.48	0.48	0.48	0.48
Range		43.00	23.00	46.00	29.00	29.00	31.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		55.00	23.00	61.00	36.00	31.00	39.00
Percentiles	25	12.00	3.00	16.00	10.00	4.00	20.00
	50	15.00	6.00	18.00	14.00	7.00	24.00
	75	20.00	10.00	25.00	21.00	13.00	29.00

Table 4.12 a displaying the descriptive statistics of the ice-cream van group

Without ice-cream van		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		146	146	146	146	146	146
Mean		19.92	9.65	25.68	17.29	12.19	22.80
Std. Error of Mean		0.75	0.48	1.01	0.61	0.72	0.43
Median		17.00	9.00	21.25	16.75	10.00	23.00
Std. Deviation		9.09	5.84	12.26	7.43	8.66	5.24
Variance		82.59	34.12	150.32	55.18	75.03	27.42
Skewness		1.57	0.81	1.69	0.64	1.04	0.23
Std. Error of Skewness		0.20	0.20	0.20	0.20	0.20	0.20
Kurtosis		2.01	0.47	3.02	-0.26	0.08	0.53
Std. Error of Kurtosis		0.40	0.40	0.40	0.40	0.40	0.40
Range		37.00	29.00	62.00	30.00	33.00	32.00
Minimum		12.00	1.00	15.00	7.00	2.00	9.00
Maximum		49.00	30.00	77.00	37.00	35.00	41.00
Percentiles	25	13.00	5.00	16.88	12.00	5.00	19.00
	50	17.00	9.00	21.25	16.75	10.00	23.00
	75	24.00	13.25	32.00	22.00	16.00	26.00

Table 4.12 b displaying the descriptive statistic of the group without ice-cream van

Table 4.13 shows the results of the Mann–Whitney tests in which confusion, depression, tension, vigour, and TMD showed significant relationships with the presence of an ice-cream van [p<.05]. Furthermore, the anger and fatigue categories showed a two-tailed non-significant result [p>.05].

Table 4.13 Mann–Whitney test of mood states categories related to the ice-cream van

	Emotion Category	Group	Median	p-value (2-tailed)	Mann–Whitney Test (U)	Z-value	Effect Size (r)
Ice-cream Van	Anger	Yes No	15.00 17.00	0.052 (ns)	6177.50	-1.94	-0.12
	Confusion	Yes No	6.00 9.00	<0.001 (sig)	5225.50	-3.69	-0.24
	Depression	Yes No	18.00 21.25	0.005 (sig)	5724.50	-2.77	-0.18
	Fatigue	Yes No	24.00 16.75	0.056 (ns)	6189.50	-1.91	-0.12
	Tension	Yes No	7.00 10.00	0.005 (sig)	5708.00	-2.80	-0.18
	Vigour	Yes No	24.00 23.00	0.041 (sig)	6117.00	-2.04	-0.13
	Total Mood Disturbance (TMD)	Yes No	37.00 52.50	0.001 (sig)	5382.50	-3.39	-0.22

Significance: p<0.05; small effect: r=0.10; medium effect r=0.20; large effect r=0.5

A further simple regression was conducted to identify the intensity and direction of these effects. The results showed that confusion [R=.229, R^2=.052, B=-2.62, p<.001, sig.], depression [R=.166, R^2=.028, B=-3.81, p<.05, sig.], fatigue [R=.116, R^2=.013, B=-1.74, p<.05, sig], tension [R=.202, R^2=.041, B=-3.25, p<.05, sig.], and TMD [R=.198, R^2=.039, B=-14.93 p<.05, sig.] all had significant negative relationships with the presence of an ice-cream van, whereas vigour [R=.127, R^2=.016, B=1.47, p<.05, sig.] had a positive relationship with it.

The ice-cream van was parked and did not produce any sounds apart from the occasional conversation between the salesperson and customers; the van was mostly quiet, or the sound was non-dominant. An assumption was therefore made that the sight, rather than the sound, of the ice-cream van, had a more positive impact on emotional responses, as it reduced the rating of negative mood states.

4.3.3.3 Street vendor

As shown in Tables 4.14 a and 4.14 b, the descriptive statistic of both the street vendor and the non-street vendor groups show skewness and kurtosis values not close to 0, and the size between the two participant groups differed significantly. Hence, a non-parametric test (Mann–Whitney test) was implemented for further analysis.

With vendor		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		53	53	53	53	53	53
Mean		17.98	7.02	22.02	14.06	8.56	24.18
Std. Error of Mean		0.99	0.70	1.38	0.91	0.83	0.76
Median		14.00	5.00	17.00	12.00	7.00	24.00
Std. Deviation		7.22	5.12	10.01	6.62	6.01	5.55
Variance		52.17	26.21	100.21	43.82	36.11	30.76
Skewness		1.28	1.19	2.06	1.29	1.69	0.18
Std. Error of Skewness		0.33	0.33	0.33	0.33	0.33	0.33
Kurtosis		0.57	1.46	4.37	1.60	3.58	-0.25
Std. Error of Kurtosis		0.64	0.64	0.64	0.64	0.64	0.64
Range		24.00	23.00	46.00	29.00	29.00	24.00
Minimum		12.00	0.00	15.00	7.00	2.00	13.00
Maximum		36.00	23.00	61.00	36.00	31.00	37.00
Percentiles	25	12.00	3.00	15.00	9.00	4.50	21.25
	50	14.00	5.00	17.00	12.00	7.00	24.00
	75	21.50	10.00	25.00	18.50	10.50	27.50

Table 4.14 a displaying descriptive statistic of the street vendor group

Without vendor		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		192	192	192	192	192	192
Mean		19.41	9.03	24.73	17.29	11.52	23.17
Std. Error of Mean		0.64	0.41	0.84	0.53	0.60	0.41
Median		16.00	8.00	21.00	16.25	9.50	23.00
Std. Deviation		8.93	5.71	11.58	7.41	8.28	5.68
Variance		79.80	32.56	134.06	54.84	68.49	32.29
Skewness		1.78	0.87	1.78	0.58	1.10	0.15
Std. Error of Skewness		0.18	0.18	0.18	0.18	0.18	0.18
Kurtosis		2.97	0.52	3.48	-0.37	0.37	0.18
Std. Error of Kurtosis		0.35	0.35	0.35	0.35	0.35	0.35
Range		43.00	30.00	62.00	30.00	33.00	33.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		55.00	30.00	77.00	37.00	35.00	41.00
Percentiles	25	13.00	5.00	16.00	11.63	5.00	19.00
	50	16.00	8.00	21.00	16.25	9.50	23.00
	75	22.75	13.00	29.00	22.00	15.00	26.88

Table 4.14 b displaying descriptive statistic of the non-street vendor group

Table 4.15 shows the results of the Mann–Whitney tests in which confusion, fatigue, tension, and TMD had significant relationships with the presence of a street vendor [p<.05]. Furthermore, the depression mood category showed a two-tailed non-significant result [p>.05] that might be significant as a one-tailed result.

Table 4.15 Mann–Whitney test of mood states categories related to the street vendor

	Emotion Category	Group	Median	p-value (2-tailed)	Mann–Whitney Test (U)	Z-value	Effect Size (r)
Street Vendor	Anger	Yes	14.00	0.269 (ns)	4585.50	-1.11	-0.07
		No	16.00				
	Confusion	Yes	5.00	0.014 (sig)	3974.50	-2.44	-0.16
		No	8.00				
	Depression	Yes	17.00	0.053 (ns)	4208.00	-1.94	-0.12
		No	21.00				
	Fatigue	Yes	12.00	0.002 (sig)	3712.50	-3.02	-0.19
		No	16.25				
	Tension	Yes	7.00	0.033 (sig)	4119.50	-2.13	-0.14
		No	9.50				
	Vigour	Yes	24.00	0.284 (ns)	4598.50	-1.07	-0.07
		No	23.00				
	Total Mood Disturbance (TMD)	Yes	34.00	0.014 (sig)	3964.50	-2.46	-0.16
		No	49.50				

Significance: p<0.05; small effect: r=0.10; medium effect r=0.20; large effect r=0.5

A simple regression test was conducted, and the results demonstrated that confusion [R=.147, R^2=.022, B=-2.01, p<.05, sig.], fatigue [R=.181, R^2=.033, B=-3.23, p<.05, sig.], tension [R=.154, R^2=.024, B=-2.96, p<.05, sig.], and TMD [R=.148, R^2=.022, B=-13.34, p<.05, sig.] had significant negative relationships with the street vendor's presence.

The sound of the street vendor consisted of conversations with customers and the vendor's hawking. These sounds were non-dominant human voices that blended into the regular voices on the street, like the ice-cream van. The street vendor produced a similar result to the ice-cream van, where negative moods were decreased, which may indicate that vendors in public urban spaces have an overall positive impact on mood state. Further study is required to examine this assumption.

4.3.3.4 Children's sounds

Descriptive statistics of the children and the non-children groups showed that the data distribution of the two groups violated the normality assumption (i.e. the skewness and kurtosis values are not equal or close to 0) (see Tables 4.16 a and 4.16 b). Hence a non-parametric statistic model (Mann–Whitney test) was used for further analysis.

with children sound		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		41	41	41	41	41	41
Mean		17.73	7.48	23.23	15.71	8.95	25.01
Std. Error of Mean		1.19	0.84	1.74	1.07	1.09	0.95
Median		15.00	6.00	19.00	15.00	7.00	25.00
Std. Deviation		7.65	5.36	11.12	6.86	7.00	6.06
Variance		58.45	28.70	123.70	47.05	48.95	36.69
Skewness		2.18	1.46	1.98	0.75	1.86	0.01
Std. Error of Skewness		0.37	0.37	0.37	0.37	0.37	0.37
Kurtosis		6.13	2.77	4.50	0.14	4.28	1.52
Std. Error of Kurtosis		0.72	0.72	0.72	0.72	0.72	0.72
Range		37.00	26.00	51.00	27.00	33.00	33.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		49.00	26.00	66.00	34.00	35.00	41.00
Percentiles	25	12.00	3.50	15.50	10.50	4.00	22.00
	50	15.00	6.00	19.00	15.00	7.00	25.00
	75	20.50	9.75	26.00	20.50	12.50	29.00

Table 4.16 a displaying descriptive statistic of the children sounds group

without children sound		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N		204	204	204	204	204	204
Mean		19.37	8.82	24.33	16.77	11.26	23.06
Std. Error of Mean		0.61	0.40	0.79	0.52	0.56	0.39
Median		16.00	8.00	20.00	15.50	9.00	23.00
Std. Deviation		8.77	5.68	11.35	7.45	8.06	5.53
Variance		76.90	32.22	128.73	55.51	64.94	30.60
Skewness		1.68	0.84	1.81	0.68	1.14	0.15
Std. Error of Skewness		0.17	0.17	0.17	0.17	0.17	0.17
Kurtosis		2.61	0.42	3.59	-0.25	0.48	-0.24
Std. Error of Kurtosis		0.34	0.34	0.34	0.34	0.34	0.34
Range		43.00	30.00	62.00	30.00	32.00	28.00
Minimum		12.00	0.00	15.00	7.00	2.00	9.00
Maximum		55.00	30.00	77.00	37.00	34.00	37.00
Percentiles	25	13.00	5.00	16.00	10.13	5.00	19.13
	50	16.00	8.00	20.00	15.50	9.00	23.00
	75	22.75	12.00	28.00	21.75	14.00	26.00

Table 4.16 b displaying descriptive statistic of the non-children sound group

Mann–Whitney test results showed that only vigour was significantly affected by the presence of children’s sounds [$Mdn_{presence}$=25.00, $Mdn_{not\text{-}presence}$=23.00, U=3300.00, Z=-2.13, r=-0.14, p<.05, sig.]. Additionally, the tension mood category showed a two-tailed non-significant [p=.071, ns] result that might be a significant one-tailed result (see Table 4.17). Therefore, a simple regression test was conducted, which found that vigour had a significant negative relationship with children's sounds [R=.129, R^2=.017, B=-1.94, p<.05, sig.], while tension had a non-significant negative relationship [R=.109, R^2=.012, B=-2.31, p>.05, ns]. These results suggest that children's sounds improved vigour scores, but had little effect on neutralising negative moods.

Table 4.17 Mann-Whitney test of mood states categories related to Children Sound

	Emotion Categories	Groups	Median	p Value (2-tailed)	Mann-Whitney test (U)	Z value	Effective Size (r)
Children Sound	Anger	Yes	15.00	0.202 (ns)	3656.00	-1.28	-0.08
		No	16.00				
	Confusion	Yes	6.00	0.159 (ns)	3598.50	-1.41	-0.09
		No	8.00				
	Depression	Yes	19.00	0.363 (ns)	3806.00	-0.91	-0.06
		No	20.00				
	Fatigue	Yes	15.00	0.452 (ns)	3870.00	-0.75	-0.05
		No	15.50				
	Tension	Yes	7.00	0.071 (ns)	3437.00	-1.80	-0.12
		No	9.00				
	Vigour	Yes	25.00	0.033 (sig)	3300.00	-2.13	-0.14
		No	23.00				
	Total Mood Disturbance (TMD)	Yes	42.00	0.11 (ns)	3520.50	-1.60	-0.10
		No	47.50				

Significance: p<0.05; small effect: r=0.10; medium effect r=0.20; large effect r=0.5

4.3.4 Effect of natural sounds

4.3.4.1 Water fountain

The descriptive statistics of the fountain sound and the non-fountain sound groups are shown in Tables 4.18 a and 4.18 b. The skewness and kurtosis values of the two groups deviate greatly from 0, indicating that the data was not normally distributed. Hence, a non-parametric statistical test (Mann-Whiney test) was used for further analysis.

With fountain sound		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N	Valid	99	99	99	99	99	99
Mean		19.40	9.37	25.81	18.65	11.37	23.47
Std. Error of Mean		0.93	0.61	1.32	0.78	0.87	0.62
Median		16.00	8.00	21.50	18.00	9.00	23.00
Std. Deviation		9.24	6.11	13.14	7.79	8.63	6.19
Variance		85.35	37.33	172.61	60.67	74.51	38.28
Skewness		1.98	0.92	1.81	0.41	1.13	0.23
Std. Error of Skewness		0.24	0.24	0.24	0.24	0.24	0.24
Kurtosis		3.85	0.58	3.24	-0.60	0.42	0.04
Std. Error of Kurtosis		0.48	0.48	0.48	0.48	0.48	0.48
Range		43.00	30.00	62.00	30.00	33.00	33.00
Minimum		12.00	0.00	15.00	7.00	2.00	8.00
Maximum		55.00	30.00	77.00	37.00	35.00	41.00
Percentiles	25	13.00	5.00	16.00	12.00	5.00	19.00
	50	16.00	8.00	21.50	18.00	9.00	23.00
	75	22.00	14.00	30.00	24.00	15.00	28.00

Table 4.18 a displaying descriptive statistic of the fountain sound group

Without fountain sound		Anger	Confusion	Depression	Fatigue	Tension	Vigour
N	Valid	146	146	146	146	146	146
Mean		18.89	8.07	23.01	15.19	10.54	23.34
Std. Error of Mean		0.68	0.43	0.81	0.56	0.61	0.44
Median		15.00	7.00	19.00	14.00	8.00	23.00
Std. Deviation		8.16	5.25	9.74	6.71	7.42	5.29
Variance		66.62	27.52	94.79	45.08	55.04	27.98
Skewness		1.50	0.84	1.55	0.89	1.28	0.04
Std. Error of Skewness		0.20	0.20	0.20	0.20	0.20	0.20
Kurtosis		1.83	0.35	1.96	0.32	1.09	0.02
Std. Error of Kurtosis		0.40	0.40	0.40	0.40	0.40	0.40
Range		36.00	25.00	46.00	29.00	31.00	28.00
Minimum		12.00	0.00	15.00	7.00	2.00	9.00
Maximum		48.00	25.00	61.00	36.00	33.00	37.00
Percentiles	25	13.00	4.00	16.00	10.00	5.00	20.00
	50	15.00	7.00	19.00	14.00	8.00	23.00
	75	23.00	11.00	26.50	19.00	13.00	26.00

Table 4.18 b displaying descriptive statistics of the non-fountain sound group

The Mann–Whitney tests revealed that fatigue had a significant relationship with the sound of water [$Mdn_{presence}$=18.00, $Mdn_{not\text{-}presence}$=14.00, U=5307.00, Z=-3.53, r=-0.23, p<.001, sig.]. A further simple regression was conducted to test the direction of this effect, which revealed that fatigue had a significant positive relationship with this sound [$R=.231$, $R^2=.054$, $B=3.46$, $p<.001$, sig.] (see Table 4.19).

Table 4.19 Mann-Whitney test of Emotional Response in Relation to Water sound

	Emotion Categories	Groups	Median	p Value (2-tailed)	Mann-Whitney test (U)	Z value	Effective Size (r)
Water Fountain	Anger	Yes No	16.00 15.00	0.639 (ns)	6972.50	-0.47	-0.03
	Confusion	Yes No	8.00 7.00	0.122 (ns)	6387.50	-1.55	-0.10
	Depression	Yes No	21.50 19.00	0.120 (ns)	6385.50	-1.55	-0.10
	Fatigue	Yes No	18.00 14.00	<0.001 (sig)	5307.50	-3.53	-0.23
	Tension	Yes No	9.00 8.00	0.832 (ns)	7111.00	-0.21	-0.01
	Vigour	Yes No	23.00 23.00	1.000 (ns)	7227.00	0.00	0.00
	Total Mood Disturbance (TMD)	Yes No	53.00 42.50	0.125 (ns)	6392.00	-1.53	-0.10

Significance: p<0.05; small effect: r=0.10; medium effect r=0.20; large effect r=0.5

This result may seem contrary to previous studies, where natural sound was found to have a positive impact on the sound environment (Hao et al., 2016; Jeon et al., 2010). However, Jeon et al. (2010) tested several water sounds as maskers of traffic and construction noise and found that only streams and waves had a positive preference rating, whereas sounds like waterfalls or rainfall had a negative preference rating. Rådsten-Ekman et al. (2013) found similar results: waterfall sounds either had no effect on pleasantness or were the least pleasant of water sounds. In a subsequent study, Rådsten Ekman, Lundén and Nilsson (2015) concluded that a high-flow-rate fountain could generate steady-state sounds, which were inherently unpleasant regardless of the pressure level, in contrast to soft, variable fountain sounds. The water sound in the present study came from fountains that produced a waterfall-like, steady-state sound; therefore, the abovementioned studies support the present results.

4.3.4.2 Birdsong

The Mann–Whitney tests demonstrated that birdsong did not have a significant relationship with any of the six mood categories [$p>.05$, ns], which could be the result of the non-dominant position and relative quietness of birdsong in this survey. In another study, birdsong was reported to be an effective masker of urban noise in some conditions; however, when the traffic was loud enough, the birdsong was ineffective (Hao et al., 2016).

4.3.5 Analysis of the interrelationship of multi-variables

To discover further interrelationships among all independent variables and how they affected mood states, multiple regression was used. No one-to-one comparison was possible between variables for two reasons. First, since the experimental design variables were not mutually exclusive, they were impossible to separate without disposing of the majority of the data. Second, when data sets are non-parametric, t-tests or ANOVAs are not very reliable. Therefore, multiple regression was used to explore the variables. The analysis began with the direct result report before exploration was undertaken and conclusions were made based on the significant results and β-values of the outcome.

The test was entered block-wise, and each block was a forced entry. The entry order was based on the significance of the result of the previous analyses in the present study (with sound variables as the focus). Block one consisted of street performance and shop music; block two consisted of fountain sounds, children’s sounds and birdsong; block three incorporated traffic sounds and amusement ride sounds; and block four involved all the non-sound related variables, namely the ice-cream van, street vendor, temperature, and weather conditions. The results were as follows:

a) Anger mood category, in Step 1 [$F(2,241)=2.07$, $R^2=.017$], Step 2 [$F(5,238)=1.80$, $\Delta R^2=.019$], Step 3 [$F(7,236)=1.37$, $\Delta R^2=.003$], and Step 4 [$F(11,232)=1.06$, $\Delta R^2=.009$], no significant regression equation was found [$p>.05$];

b) For confusion, in Step 1 [$F(2,241)=8.43$, $R^2=.065$], Step 2 [$F(5,238)=6.19$, $\Delta R^2=.050$], Step 3 [$F(7,236)=4.77$, $\Delta R^2=.009$], and Step 4 [$F(11,232)=4.65$, $\Delta R^2=.057$], a significant regression equation was found in each model [$p<.001$];

c) For depression, in Step 1 [$F(2,241)=4.24$, $R^2=.034$], Step 2 [$F(5,238)=4.36$, $\Delta R^2=.050$], Step 3 [$F(7,236)=3.44$, $\Delta R^2=.009$], and Step 4 [$F(11,232)=2.95$, $\Delta R^2=.030$], a significant regression equation was found in each model [$p<.01$];

d) For fatigue, in Step 1 [$F(2,241)=7.82$, $R^2=.061$], Step 2 [$F(5,238)=7.73$, $\Delta R^2=.079$], Step 3 [$F(7,236)=5.63$, $\Delta R^2=.003$], and Step 4 [$F(11,232)=3.81$, $\Delta R^2=.010$], a significant regression equation was found in each model [$p<.001$];

e) And for vigour, in Step 1 [$F(2,241)=0.46$, R2=.004], Step 2 [$F(5,238)=1.46$, $\Delta R^2=.026$], Step 3 [$F(7,236)=1.04$, $\Delta R^2<.001$], and Step 4 [$F(11,232)=1.02$, $\Delta R^2=.016$], a significant regression equation was found in each model [$p>.05$]. From the R^2 value, it appears that technical sounds are generally not good predictors (compared to other sound-related predictors) of mood state in an urban pedestrian area.

As shown in Table 4.20, in terms of predicting mood state by soundscape factors, Model 3 seemed to show the most significant results. Although the anger and vigour categories were mostly statistically insignificant, several conclusions could still be drawn based on the standardised beta values.

Table 4.20 **β values for hierarchical multiple regression between all environmental stimuli**

Variable	Anger (β)	Confusion (β)	Depression (β)	Fatigue (β)	Tension (β)	Vigour (β)
Step 1						
Street Performance	-0.061	-0.23***	-0.16*	-0.25***	-0.16*	0.062
Shop Music	0.106	0.08	0.07	0.01	0.11	0.001
Step 2						
Street Performance	-0.040	-0.20**	-0.12	-0.16*	-0.15*	0.080
Shop Music	0.122	0.10	0.10	0.07	0.12	0.014
Fountain Sound	0.174	0.26**	0.30***	0.38***	0.22*	-0.092
Children's Sounds	-0.161*	-0.27**	-0.22*	-0.29***	-0.25**	0.20*
Birdsong	-0.094	-0.14*	-0.19**	-0.09	-0.15*	0.066
Step 3						
Street Performance	-0.035	-0.19**	-0.10	-0.17*	-0.14*	0.079
Shop Music	0.136	0.12	0.12	0.09	0.14*	0.012
Fountain Sound	0.197	0.30**	0.33***	0.41***	0.25*	-0.095
Children's Sounds	-0.161*	-0.27**	-0.22**	-0.29***	-0.25**	0.20*
Birdsong	-0.094	-0.14*	-0.19**	-0.09	-0.15*	0.066
Traffic Sound	0.092	0.20	0.21	0.00	0.14	-0.014
Amusement Ride Sound	0.126	0.24	0.24	0.07	0.19	-0.018
Step 4						
Street Performance	-0.046	-0.21**	-0.11	-0.19**	-0.16*	0.097
Shop Music	0.097	0.01	0.06	0.04	0.04	0.094
Fountain Sound	0.187	0.21	0.33**	0.31**	0.08	0.022
Children's Sounds	-0.085	-0.12	-0.10	-0.26**	-0.20*	0.171
Birdsong	-0.084	-0.10	-0.15*	-0.08	-0.12	0.060
Traffic Sound	0.155	0.44**	0.34	0.06	0.31	-0.167
Amusement Ride Sound	0.153	0.36*	0.31	0.08	0.25	-0.089
Ice-cream Van	-0.108	-0.32**	-0.29*	0.02	-0.08	0.054
Street Vendor	0.047	0.04	0.14	-0.12	-0.16	0.130
Weather	0.057	0.09	0.07	-0.04	-0.05	-0.021
Temperature	-0.067	-0.05	-0.03	-0.05	-0.01	0.018

Note. N=244; *p<.05, **p<.01, ***p<.001

First, when street performance and shop music were combined with fountain sounds, birdsong, and children's sounds (from Step 1 to Step 2), the β-values of the two music predictors were always increased for all negative moods. This β-value increase for negative moods appeared again when predictor traffic sounds and amusement ride sounds were added (from Step 2 to Step 3). This result may indicate that a combination of multiple sound sources masks the potential positive effect of music on negative mood states and increases the negative effect on negative mood states, regardless of the sound source's effect on the negative mood categories. In contrast, the vigour mood category (a positive mood state) did not seem to follow this trend: its β-value rose if the combined sound positively affected the vigour mood state, while the β-value fell if it negatively affected the state. Second, based on the β-value from Step 2 to Step 3, the relationship between fountain sounds and mood states was negatively affected if combined with sound sources that negatively affect mood states (e.g. technical sounds). Finally, also based on the β-value from Step 2 to Step 3, the relationship between birdsong or children's sounds and mood states seemed unaffected by traffic and mechanical sounds. It is important to note that all these assumptions are drawn from an urban pedestrian context.

4.3.6 Analysis of underlining components

The POMS contained 6 mood state categories that were originally discovered through the means of exploratory factor analysis (EFA). As the thesis study used the questionnaire under conditions that were different from what POMS was originally developed for (i.e. in medical settings, to monitor patients' mood states) it was necessary to re-examine the underlying factors that were measured in this thesis. Similar to the development of POMS, the re-examination of the underlying factors was accomplished by PCA (similar to factor analysis), where all 65 items from POMS were re-mapped under different factors based on their factor loading.

A PCA was conducted on 65 items (of the POMS) with oblique rotation (promax, kappa = 4). The Kaiser-Meyer-Olkin sampling adequacy measure of (KMO) = .92 indicating the data were adequate for PCA (Kaiser, 1974), and recommends a bare minimum KMO value of 0.5 for the sample to be adequate). Bartlett's test of sphericity X^2 (2080) = 11381.95, $p < .001$ indicating correlation between items was sufficient for PCA. Eigenvalues of each of the 13 item components were discovered based on Kaiser's criterion: eigenvalues over 1). In combination the 13 components explained 68.39% of the total variance (see Table 4.21).

Components	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	21.41	32.94	32.94	21.41	32.94	32.94	18.50
2	5.52	8.50	41.44	5.52	8.50	41.44	16.01
3	2.95	4.55	45.99	2.95	4.55	45.99	13.43
4	2.43	3.74	49.73	2.43	3.74	49.73	11.55
5	1.95	2.99	52.72	1.95	2.99	52.72	4.62
6	1.68	2.58	55.30	1.68	2.58	55.30	10.43
7	1.50	2.31	57.61	1.50	2.31	57.61	4.98
8	1.30	2.00	59.61	1.30	2.00	59.61	2.03
9	1.27	1.96	61.57	1.27	1.96	61.57	3.66
10	1.19	1.83	63.40	1.19	1.83	63.40	4.70
11	1.16	1.78	65.18	1.16	1.78	65.18	2.15
12	1.07	1.65	66.83	1.07	1.65	66.83	3.50
13	1.02	1.56	68.39	1.02	1.56	68.39	1.98

Table 4.21 Total variance. Initial analysis based on eigenvalues, only showing components with eigenvalues above 1 (Kaiser's criterion)

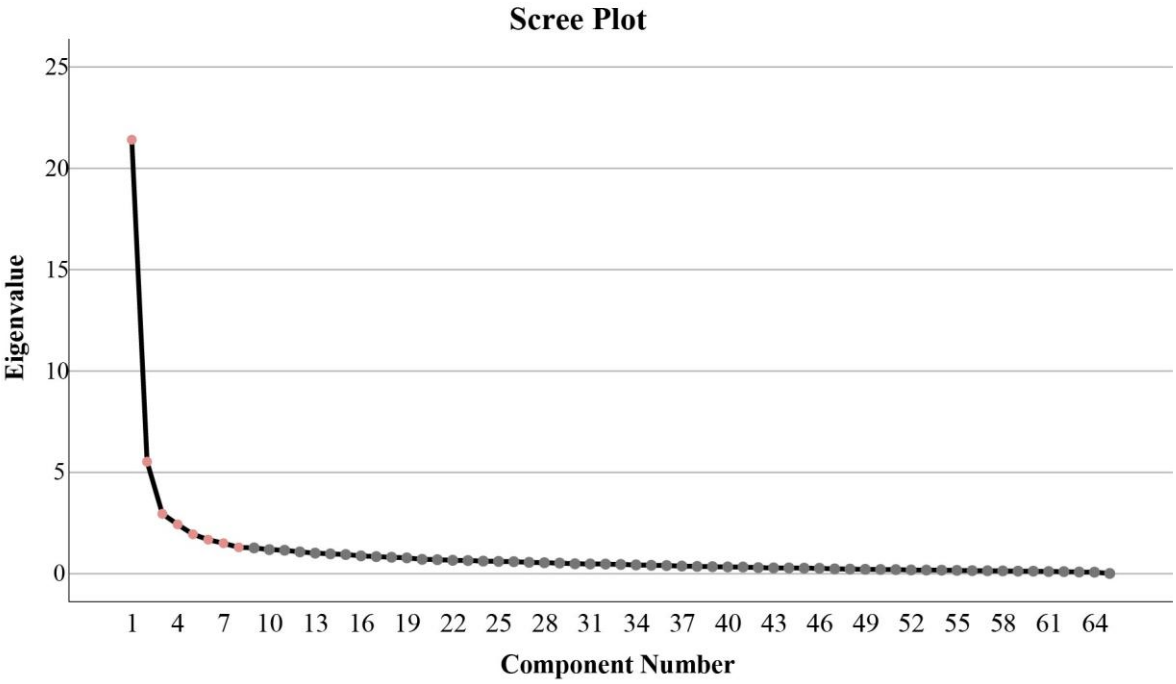

Figure 4.9 Scree plot of eigenvalue against components

The scree plot (Figure 4.9) shows the point of inflexion is at the 8th component. Based on both the eigenvalues and the scree plot, keeping both 8 and 13 components is justifiable.

Although 8 components are more in agreement with POMS' original categorisation (6 mood states and redundant items) all 13 components were examined.

	Component												
Items	1	2	3	4	5	6	7	8	9	10	11	12	13
Worthless	1.13												
Hopeless	1.00												
Helpless	0.88												
Unworthy	0.86												
Miserable	0.78												
Sad	0.75												
Guilty	0.66												
Lonely	0.66												0.44
Blue	0.65												
Unhappy	0.63			0.40									
Desperate	0.52												
Uncertain about things	0.51												
Unable to concentrate	0.50												
Gloomy	0.45												
Discouraged *							—						
Nervous		0.91											
Anxious		0.85											
Panicky		0.85											
Uneasy		0.69											
Terrified		0.61											0.45
On edge		0.55											
Shaky		0.55											
Restless		0.54											
Tense		0.54		0.52									
Muddled		0.51											
Confused*							—						
Listless*							—						
Exhausted			0.96										
Fatigued			0.94										
Worn_out			0.87										
Bushed			0.76										
Weary			0.72										
Sluggish			0.66										
Forgetful*							—						
Peeved				0.86									
Angry				0.83									
Annoyed				0.76									

Resentful*	—												
Good-natured					0.81								
Helpful					0.78								
Considerate					0.77								
Friendly					0.72								
Sympathetic					0.63								
Full of pep					0.44							-0.41	
Ready to fight						0.99							
Furious						0.74							
Bad-tempered						0.61							
Rebellious						0.52				0.41			
Deceived						0.51							
Energetic							1.05						
Activity							1.04						
Efficient								0.75					
Alert								0.60					
Carefree									0.88				
Relaxed		-0.41							0.53				
Clear-headed								0.40	0.42				
Cheerful*	—												
Vigorous										0.86			
Spiteful											0.64		
Bitter											0.47		
Lively											-0.41		
Trusting					0.55							-0.76	
Bewildered*	—												
Sorry for things done													0.57
Grouchy*	—												

Table 4.22 Pattern matrix of unique factor loadings after factor rotations in the order containing the most items to the least items

* unique factor loading below 0.4

Table 4.22 shows the unique factor loadings of all items corresponding to the 13 components after factor rotation. The table also provides the order of the components in the numbers of items that are attributed to each component from the most to least. Following this order, the mood states represented in each component are as follows: 1) depression (contain 12 depression items 2 non-depression items), 2) tension (contain 9 tension items and 2 other non-tension items), 3) fatigue (contain 6 fatigue items), 4) anger (contain 3 anger items, 2 non-anger items that related to emotional distress), 5) friendliness (contain 6 friendly personality trait items and 1 vigour item), 6) anger (contain 5 anger items), 7) vigour (contain 2 vigour items), 8) reverse confusion (contains 1 reverse confusion item, 2 other items that could be interpreted as reverse confusion), 9) vigour (contains 1 vigour item and 2 other items that could be interpreted as vigour), 10) vigour (contains 1 vigour item and 1 non-vigour item that could be interpreted as vigour), 11) anger (contain 2 anger items and 1 vigour item), 12) component 12 has 2 items that are too ambiguous to attributed to a mood state, 13) depression (contain 3 depression items) (see also Table 4.23).

Components	1	2	3	4	5	6	7	8	9	10	11	12	13
Distinctive emotion	Depression	Tension	Fatigue	Anger	Friendliness	Anger	Vigour	Reverse confusion	Vigour	Vigour	Anger	—	Depression
Items (emotional related words)	Worthless	Nervous	Exhausted	Peeved	Good natured	Ready to fight	Energetic	Clear headed*	Carefree	Vigorous	Spiteful		Sorry for things done
	Hopeless	Anxious	Fatigued	Angry	Helpful	Furious	Activity				Bitter		Terrified*
	Helpless	Panicky	Worn out	Annoyed	Considerate	Bad tempered							Lonely*
	Unworthy	Uneasy	Bushed		Friendly	Rebellious*							
	Miserable	On edge	Weary		Sympathetic	Deceived							
	Sad	Shaky	Sluggish		Trusting*								
	Guilty	Restless											
	Blue	Relaxed*											
	Desperate	Tense*											
	Gloomy												
	Lonely*												
	Unhappy*												
Numbers of items related to	12	9	6	3	6	5	2	1	1	1	2	2	3
Items did not fit the mood states categories	Uncertain about things	Terrified*		Tense*	Full of pep*			Efficient	Relaxed*	Rebellious*	Lively	Full of pep*	
	Unable to concentrate	Muddled		Unhappy*				Alert	Clear headed*			Trusting*	

* items that shared between two components

Table 4.23 list of items attributed to each component and the underlying mood state that represented each component

As shown in Table 4.23, the 6 mood states proposed in POMS were covered by the first 8 components in the PCA results, the only difference being that component 5 was attributed to 'friendly'. This difference was not unusual as another study also discovered the same friendly components within the POMS (Gibson, 1997). In Gibson's (1997) study, the 'friendly' component was composed of items that were considered redundant by POMS, and this same result was also reached in this study (see component 5 in Table 4.23). Even by including the friendly element, the first eight components from PCA still contained one more component than that proposed by POMS, which was due to the splitting the anger mood into two components (components 4 and 6). This splitting indicates that there were further underlying components within the emotion/mood anger categories. Based on the items composing the two components (see components 4 and 6 in Table 4.23), it was hypothesised that the difference between the two components was captured by the difference between items explaining the anger emotion as whole and the actions and/or derivative emotions it could elicit.

The resulting components higher than component 8 were a small collection of items that distributed among vigour (2 items), anger (1 item) and depression (1 item) (see Table 4.23). Although these components were labelled based on the common theme of the items they contained, the numbers of items were too small to be attributed to any particular mood state with any certainty. One mood state worth pointing out is vigour. In the PCA result, vigour was split among three components (components 7, 8 and 9) with each containing less than 2 items. This split in components together with the small number of vigour items that each component contained indicates that any results based on vigour mood states were less likely to be genuine. Within the PCA results, several items were attributed to different components that were too ambiguous to be assigned a category, as they do not fit the mood/emotional theme labelled to their components (see row 'Items did not fit the mood states categories' in Table 4.23). These ambiguous items were likely caused both by misunderstanding and misinterpretation of the items and the attention loss of participants during survey sessions. However, the ambiguous items that were attributed to each component were few (less than two) and were unlikely to have affected interpretation of the main result of the mood states they were in.

In summary, the PCA produced similar components (mood states) as the original POMS proposed. Although several differences were observed, they were unlikely to have affected interpretation of the results (of MANOVA) based on the 6 mood states of POMS. The only potentially problematic mood state was vigour, as the vigour mood state was scattered across three components with only a small numbers of items making any results derived from vigour unreliable.

4.4 Discussion

4.4.1 Appraisal processes of each mood category

Appraisal theory provides a way to analyse the emotional effect discovered in the data analysis. The following sections aim to explore the factors of these effects in terms of their person-environment relationship, core relational theme, appraisal patterns and/or their roles in the corresponding emotional responses.

4.4.1.1 Anger

Anger as a mood category did not show any significant changes. This was expected, as an urban environment rarely provide environmental stimuli appraised as an attack on people’s ego-identity or an intentional obstruct to a person’s goal. Few environmental events such as the fire alarm from an adjacent building, although anticipated by the research to have the potential to be able to interrupt participants goals, lacked the ‘intentional’ aspect. Events such as the fire alarm in this study were mostly elicited with a startled or surprised response, and this uncertainty is a core relational feature of anxiety rather than anger. Together with a very small occurrence rate of goal interrupting events, all contributed to the non-significant response in anger emotion.

4.4.1.2 Confusion

Confusion as a mood category emphasises the situation where people have difficulty understanding the encountered environments, and may lead to other emotional responses or not forming emotion at all. Confusion itself is not an emotion or mood; rather it reflects a situation in the appraisal process (see also Section 3.6.3). It was observed that confusion had a significant negative relationship with the presence of street music, ice-cream van and street vendor. This implies that these environmental factors reduce the overall difficulty to understand an environment compared to ones without them. It also means that people are more likely to form a person-environment relationship with these three factors. This assumption is further proved by the relationships discovered between mood/emotional categories and these three factors which were far more in number (3 to 5 mood categories) compared to other factors (0 to 1 mood categories).

4.4.1.3 Depression

Depression, similar to confusion, is not an emotion per se under the definition of appraisal theory, but it could include and lead to several emotions. A significant negative relationship was found between depression and two factors (i.e. street music and ice-cream van). This implies that peoples are less likely to experience emotions that have a potential relation to depression, namely sadness, fear, worthless/guilt and anxiety (these are emotional items included in the depression category in the questionnaires). The negative relationship also means that the two factors do not encourage appraisal patterns in the same way as these negative emotions. An assumption can be made based on the relationship that the presence of the two factor could potentially reduce emotional distress. However, whether the factors are the cause of the dissipation of the distress or simply distracting people from the distress is arguable, and it may very well depend on the encountered situations. Something worth noting is that both street music and ice-cream van can be perceived with pleasantness (Aiello et al., 2016; Xu, Hamid, Shepherd, Kantono, Reay, Martinez & Spence, 2019), and this may be part of the reason why the negative correlation was observed. For music, this could be the specific music type or musical features that affected the depression and may have a different effect if music pieces are changed. For ice-cream van, it is most likely to be emotional memory associated with the ice cream or the experience of consuming it. These positive perceptions require further study but are beyond the scope of this study.

4.4.1.4 Tension (anxiety)

A tension mood category in POMS includes two parts. One is the non-emotion – tension, which implies high goal relevance and goal incongruence. In a negative emotional response, this also indicates a high intensity of the response. The other one is anxiety, and the core relational theme for anxiety is the uncertain, existential threat to ego-identity. Both parts are represented in the items under the same tension mood category. The tension category was found to have a significant negative relationship with street music, ice-cream van, and street vendor. The factors that had negative relationships with tension all provide recreational activities for people. These factors also had no potential threat nor perceived uncertainty in the encounters to further unfold. Interestingly, the shop music factor which aimed to provide a better experience for customers had a significant positive relationship with the tension mood category. This result indicates that shop music is appraised as goal incongruence, and this might have been due to the fact that the music was aimed at people shopping in the store but not necessarily for the non-customer outside of the store, and as such may have interrupted the activity of the non-customers. Since the survey did not take place in the store, no participants were customers of the stores. This opposite effect was also expected to do with the context of how the music was played, music types and the dominance of the music in the acoustic environment this was discussed in the results Section 4.3.2. The results of this positive relationship reveal that environmental factors that provide recreational function are not always necessarily perceived with positivity. It proves that the factors' role in the person-environmental relationship and its contexts are crucial to predict emotional outcomes.

4.4.1.5 Fatigue and Vigour

Fatigue and Vigour mood categories both have roles in the spending of cognitive resources. On the one hand, a fatigued state explains a situation where the cognitive resource of a person has been exhausted or mostly exhausted through the appraisal process of the environment. A vigorous state, on the other hand, means a person still possesses enough or even excessive cognitive resource to appraise or cope with the environmental encounters.

The factors that had a significant negative relationship with fatigues were street music, ice-cream van and street vendor. The negative relation between these three factors and fatigue indicates that the resource demanded by the environment to appraise it was lowered when these factors were part of the environment. Three possible assumptions could be made based on this outcome. First, if the three factors replaced other factors in the environment, it means these three factors required less cognitive resource to appraise compared to the replaced factors. Second, if the three factors distracted attention from other factors within the environment, then the three factors reduced the overall demands of cognitive resources to appraise the environment. The third assumption was that when we consider that cognitive resources can be restored during rest or relaxing activities, these three factors may have assisted in recovery of the cognitive resource. Verifying these three assumptions requires an experimental design with controlled environments. However, this was not possible under the condition of this case study and was explored in the following studies (see Chapters 5 and 6). The water fountain was the only factor that had a significant positive relation with fatigue. This indicates that the water fountain required additional cognitive resource to appraise and increased the overall requirements in cognitive resource to appraises the environment. This conclusion does not ignore the positive effect of water fountains found in many other studies; the cause of the result in this study was attributed to the steady-state sound produced by the fountain (see water fountain discussion in the results Section 4.3.4.1).

Only two factors were found to have a significant relationship with vigour. Ice-cream van had a significant positive relationship and children sound had a significant negative relationship. For ice-cream van, this means that the presence of the factor shifted the balance from the required resource to appraise the environment towards the cognitive resource a person had. This could mean: (a) restoration of the cognitive resource; (b) reduction of the resource demanded by the environment; and (c) or both. For children sound, the balance between demand and cognitive resource possessed by an individual shifted towards demands. This means the opposite is true: (a) children sound hindered the restoration of cognitive resource; (b) or the requirement resource to appraise the environment has increased; and(c) or both.

Both the shifting of fatigue and vigour states depends on the balance of resource demanded by an environment and the resource a person possesses. But the result indicates that the two states are not in a bipolar relationship, as the increase of one states did not necessarily translate into a decrease in the other. A similar argument has also been made by Shirom

(2007), where he argued that the relation between vigour and fatigue is bivariant instead of bipolar, based on biological and physiological studies.

There appears to be a boundary between the two states, without crossing it one state cannot easily transition to the other one. Furthermore, one cannot claim that reducing fatigue means an increase in vigour. This boundary appears to be whether the resource demanded by the environment exceeds the resource possessed by the individual. It is not clear whether this boundary was a clear cut value or an intermediate state with ranges, and the constant changing dynamic among resource spending and restoration only added to the complexity of the issue. To fully examine the relationship between fatigue and vigour is beyond the scope of this study.

4.4.1.6 Implicit and Explicit Emotional Process

As explained in the methodology chapter (Chapter 3), the emotional process can be both implicit and explicit. Emotional memory explains a memory of emotional outcomes resulting from a past complete conscious appraisal process. It can be triggered by environmental stimuli or encounters similar to the encounter in the memory, in turn triggering the same emotional response. This latter triggering is automatic, without or involving a very small effort of consciousness. In other words, it is an implicit emotional process. This implicit process produces an emotional response with the best match with the current environmental encounter. Hence, the emotional outcomes produced in this way are not necessarily an accurate appraisal of the encounter, but more similar to an impression of the environmental stimuli. This deduction indicates that the emotional responses produced implicitly are more likely to be universal because they are knowledge-based assessment and lacking in logical consideration of the actual environment. And peoples' impressions of environmental stimuli is likely to be the same.

There is no defined method to distinguish an implicit emotional process (an automatic unconscious one) from an explicit emotional process (a logical conscious one). In this study, some identification of the processes can be deduced based on results. In past studies, music presented in public spaces were mostly associated with a positive emotional response (Jambrošić et al., 2013; Steele *et al.*, 2016), with the same for perceiving natural sound such as water (Guastavino, 2006; Axelsson *et al.*, 2014; Pérez-Martínez et al., 2018). However, the result of this study showed shop music and water fountain had a different effect from past findings. The results showed that shop music and fountain sound were both associated with an increase in negative mood categories. The presence of shop music increased tension (anxiety) and the presence of fountain sound increased fatigue. This difference in emotional reaction between past literature and this study indicates that the two factors were most likely processed with conscious and logical thinking; hence, the emotional response are most likely produced explicitly. Other appraisal processes that can be deduced to be explicit are those processes that appeared to alter the rating of both fatigue and vigour mood categories. Change in both mood categories are dependent on the spending of cognitive energy: the appraisal process that happened implicitly do not spend much cognitive energy if at all. This indicates that the change in both mood categories is more likely to result from an explicit emotional process.

4.4.1.7 The Distraction of Environmental Factors

Within the results of this study, there is uncertainty regarding whether a result is the cause of the factor itself or a distraction caused by the factor. Distraction in this study (if it happened) was taken as meaning that the appraised environmental factor or factors had changed. Further, distraction can happen both implicitly and explicitly. If the distraction happened implicitly, it meant that the change in emotional response was caused by different emotional memory associated with the factor. If the distraction happened explicitly, it meant that the change in emotional response was caused by the change of appraisal patterns. Additionally, this explicit process also meant a change in the amount of cognitive resource spent during the appraisal process. The change in the cognitive effort spend, then, would shift the balance between cognitive resources possessed by an individual and cognitive resources required to appraises a factor, in turn, would reflect in the change in the vigour and fatigue mood categories.

4.4.2 Other observation

In the data analysis, ice-cream van and street vendor were categorised as human sounds from different activities; however, the outcomes indicated that the visual contexts, rather than the sounds, were the dominant aspects of these two variables. This conclusion led to the inclusion of visual stimuli in later studies (see Chapters 5 and 6), This conclusion also concurred with Nikolopoulou and Steemers (2003) and Robinson's (2005) studies, where context played a significnat role when people responded to physical stimuli and interpreted their emotions.

While the studied cases represented typical urban settings in Europe, for the present findings to be adaptable to a wider context, further experiments would be useful, for example, to consider more sound source types and a higher urban density or suburban context. Additionally, it would also be beneficial to develop more mood categories for soundscape studies, specifically as POMS was originally developed in a medical context.

4.5 Conclusions

This study provided a preliminary investigation into several sound-related variables and basic environmental variables in an urban public environment in Sheffield. Further, this study examined whether these variables had a significant impact on mood states, including anger, confusion, depression, fatigue, tension, and vigour. Light and temperature conditions were not found to have any significant effect on people's mood states, a finding which differed from Mehrabian and Russell's theory (Mehrabian & Russell, 1974); however, in the context of lacking of intense dramatic light condition changes in the outdoor space and the lack of significant temperature shifts on site, the results remained consistent with Mehrabian and Russell's ideas.

Sound showed various effects on mood states, depending on its origin and the contextual information contained within. Music had a significant effect on mood states, either positive or negative, depending on the context. Traffic and amusement ride sounds had no significant effect on mood states, which may be related to their routine nature and commonness in urban public spaces. However, ice-cream van and street vendor, which produced sounds that were less routine and non-dominant, had a significant impact on mood states. The sight of the ice-cream van and street vendor, rather than their sounds, could have influenced this result.

Birdsong did not have a significant effect on mood states. The sound types and their non-dominant position in this context, together with the limitation of the POMS questionnaire, may have played a large part in this result. The sound of children only had a limited effect on positive moods.

Combining multiple sound sources could mask the potential positive effect of music towards negative mood states and increase the negative effect of sound sources on mood states, regardless of how the sound source affected negative mood categories. The effect of music on positive mood states seemed to follow most of the other sound sources studied in this chapter: the relationships between these sound sources and mood were positively related to whether the combined sound source positively or negatively affected mood state.

The study's results also showed mostly small to medium effects, and the simple regression test results could only explain a small percentage of the variance. Based on these results, the effect of the environment on moods seemed to be very small. This outcome might be a result of this study's on-site survey method and urban context, which led to the inclusion of many unwanted variables during data collection that may have influenced the effectiveness of the studied variables. It was also possible that the mood state shifts caused by the environment were relatively small overall. The results and conclusion from this case study should be further examined in the controlled environment of a laboratory (see Chapters 5 and 6).

Chapter 5: Effect of sound types of an urban environment on mood states

5.1. Introduction

The previous chapter identified and examined several environmental stimuli including weather conditions, acoustic and visual stimuli. It was found that different types of sound had a significant but varying effects on participants' emotional outcomes. However, due to the in-situ condition, it was difficult to make comparisons between sound types and difficult to fully control the environmental conditions. Following this result, this chapter extracted the sound types (i.e. Street music, Traffic sound and Fountain sound) that were examined in the previous chapter and tested them in a controlled laboratory environment. The statistical data confirmed that sound types do have a significant and varied effect on emotional outcomes. However, this effect was found to be different when compared with the in-situ study. After the careful analysis through the lens of analysis appraisal effect, the chapter concludes that such differences are caused by how the sound types are presented in relation to the contexts. The experiment contained the following questions:

- How does sound type affect mood/emotions?
- How does the sound level affect mood/emotions?
- How does social demographical differences affect mood/emotions?
- Are there any other contexts beyond sound that affect mood/emotions?

5.2. Methods

In this chapter, two pilot tests and the main experiment were carried out. The two pilot tests to identify the perceived loudness of sound stimuli and determination of participant sizes, respectively. The main experiment explored the three sound types (i.e. street music, traffic sound and fountain sound), the sound level (loudness), gender differences and environmental contexts and their effect on the six categories of emotional responses (i.e. anger, tension, depression, confusion, fatigue and vigour).

5.2.1. Sound stimuli (Pilot test 1)

To simulate a natural urban acoustic environment, the sound stimuli were designed with combinations of sound types. There was no ethic approval as the test was completed by a group of research colleagues. Four sound clips were designed to provide the sound stimuli: sound clip 1 (music and fountain sound); clip 2 (fountain sound and traffic sound); clip 3 (music and traffic sound); and clip 4 (music, fountain sound, and traffic sound). Each sound type was recorded separately at Sheffield city centre, South Yorkshire, UK, with a binaural recorder (street music from the Moor Market, fountain sound from the Peace Garden, and traffic sound from Fargate Street close to Church Street) and later composed into 5-min sound clips using the *Audacity* software. The sound level was measured in terms of A-weighted Sound Pressure Level (SPL) using a *01-dB sound level meter*.

Each clip was replayed at two sound levels. The first was at a similar SPL to the original context. The SPL for the second replay was decided based on an average value in a pilot test. Based on a study by Sudarsono, Lam and Davies (2016), on average people expect the SPL of laboratory audio replay of an outdoor sound recording to be 9.5 dB lower than its original context. Six participants were recruited (four female and two male) for the test. Each clip was played to the participants individually at an SPL of 9.5 dB lower than the original context, and each participant was asked to adjust the volume to what they considered appropriate for the respective context. The results are listed in Table 5.1. The volume was adjusted in terms of decibels unweighted (dB) because adjusting it in terms of decibels weighted (dBA) was difficult. Each adjusted clip's A-weighted SPL was re-measured following the adjustments.

The average A-weighted SPL was then determined and used for the second replay of each clip.

Table 5.1 Adjusted audio volume of audio clips by six participants based on mean value

	Clip 1[a]		Clip 2[b]		Clip 3[c]		Clip 4[d]	
	dB	dBA	dB	dBA	dB	dBA	dB	dBA
1	-4.0	66.80	-14.0	56.70	-12.0	53.90	-11.0	62.70
2	1.0	70.70	-1.0	68.10	-4.0	65.30	-1.0	69.10
3	9.0	76.10	2.0	74.50	4.0	68.30	-11.0	60.50
4	-7.0	64.40	-16.0	58.80	-12.0	55.90	-7.0	64.00
5	3.0	72.30	-5.0	68.70	3.0	67.70	-4.0	66.40
6	6.0	74.40	2.0	74.40	6.0	69.90	5.0	73.40
Average	5.0	70.78	4.0	66.87	-1.0	63.50	5.0	66.02

a. street music and fountain sound
b. fountain sound and traffic sound
c. street music and traffic sound
d. street music, fountain sound, and traffic sound

The experiment used the sound level as an indicator of sound intensity. However, it did not reflect the perceived loudness on a one-to-one scale, and therefore may not accurately represent the correlation between sound intensity and mood. Several studies have indicated that sound level, especially the A-weighted sound level, was not a reliable indicator of perceived loudness. Kjellberg and Goldstein (1985) reported that the A-weighted SPL underestimated the annoyance rating owing to the low-frequency componence of sounds. In addition, Hellman and Zwicker (1987) concluded that if two different spectral-shaped sounds were combined, the A-weighted SPL could not predict the perceived loudness and annoyance of people. However, the non-weighted SPL can be converted into perceived loudness, such as Stevens loudness or Zwicker loudness (two standardised loudness measurements), through equations, both of which are more reliable indicators of perceived sound intensity (ISO 532-1:2017). Therefore, the study implemented the A-weighted SPL in the data analysis of sound intensity.

5.2.2 Participant size calculation (pilot study 2)

Several trial sessions were conducted as a pilot study to predict the power and participant size for the main study. The pilot study collected data from 21 participants for three out of four different sound stimuli groups. Pilot participants were recruited through email within the University of Sheffield. The University provided ethics approval (024266). The experiment design of the pilot study was similar to that of the main study (see Section 5.2.4). The male-to-female participant gender ratio was 3:18. Owing to this largely imbalanced ratio, the gender variable was not included in the power calculation. ANOVA was used as the model for *post hoc* power calculation because this model determines the required participant size for ideal power among all statistical models. Calculations were performed using *G*Power 3.0* software.

Table 5.2 ANOVA: Pilot study with *post hoc* sample power calculation

		Mean	Size	SD	Effect size, *f*	Power
	group 1	8.250	8			
Anger	group 2	2.750	8	6.40	0.39	0.291
	group 3	4.000	5			
	group 1	7.500	8			
Confusion	group 2	1.500	8	6.16	0.43	0.346
	group 3	3.800	5			
	group 1	11.500	8			
Depression	group 2	2.750	8	10.66	0.36	0.255
	group 3	8.000	5			
	group 1	8.750	8			
Fatigue	group 2	6.125	8	6.03	0.20	0.107
	group 3	6.600	5			
	group 1	8.250	8			
Tension	group 2	-1.750	8	7.66	0.58	0.583
	group 3	1.200	5			
	group 1	18.625	8			
Vigour	group 2	20.875	8	5.33	0.52	0.483
	group 3	25.800	5			

As indicated in Table 5.2, the overall results showed insufficient power [$1 - \beta < 0.80$]. The *post hoc* calculation was followed by an a priori sample size calculation. The calculation predicted that a total of at least 180 participants would be required to achieve a power of 80% for medium effect size [$f = 0.25$], implying at least 45 participants for each of the four stimuli groups. Achieving 80% power for small effect [$f = 0.10$] would require 1,096 participants, an impractical number for this study. However, the use of the MANOVA method, which has a greater ability to detect group differences, would prevent the small effect from going undetected (in the ANOVA). The sample size calculation predicted that 135 participants would be required to detect the small effect size [$f = 0.10$], with a power of 95% for six dependent variables (moods) and three independent variables (sound clips, gender, and realisation of sound) in the MANOVA analysis. In conclusion, it was determined that a total of 180 participants, 45 for each sound stimuli group, were required, and the gender ratio should be evenly distributed in each group.

5.2.3 Questionnaire

A long form of the POMS questionnaire was used (McNair et al., 1992). The questionnaire consisted of 65 items, with each item rated from 0 to 5. Additionally, each item could be classified into six categories of moods: anger; confusion; depression; fatigue; tension; and vigour. The rating scores of the items in each category were summed to obtain the score of the respective categories. Two open questions were added to help the participants define their moods in the mood-forming process. These questions were also used to confirm if the participants realised the sound stimuli and environmental context of the experiment. The two questions asked were: 1) 'Was there anything during the experiment session that attracted your attention, even for a brief moment?'; and 2) 'Was there anything else on your mind during the experiment session? If yes, could you summarise your thoughts (e.g. work-related thoughts)?'. See appendixes B1 and B2 for example of the questionnaire.

The collected data was then manually input into *IBM SPSS* software for analysis.

5.2.4 Experimental procedure

The experiment was conducted in a meeting room located in the Inner Mongolia University of Technology in China. To simulate the acoustic condition of exterior public spaces, sound-absorbing foam was attached to the walls of the room to control reverberation time (0.3 to 0.5s for a frequency range of 500 to 1,000 Hz). The setup of meeting room is show in Figure 5.1.

Figure 5.1 setup of the meeting room

The main experiment was ethically approved by both the Inner Mongolia University of Technology in China and the University of Sheffield (reference number 024266). Participants in this study were undergraduate students recruited from the university through an announcement made during lectures and classes. Potential participants were informed that the experiment required a total of 200 people, 100 from each gender. They were also asked to participate only if they had normal perceptibility (i.e. normal hearing and vision). Each experiment session consisted of 12 to 13 people. Upon arrival, participants were asked to spend 30 min relaxing. One of the eight audio clip variations was then played on a loop and the relevant picture was projected onto a screen in each experiment session. Any relaxing activity was allowed, if it did not interfere with the perceptibility of the participants (e.g. no headphone use). At the end of each session, participants were directed to complete a POMS questionnaire (see Figure 5.2). By the end of the experiment, 16 sessions were conducted over a period of 2 weeks (from April 29 to May 13, 2019). A total of 199 surveys were completed, with 102 female participants and 97 male participants.

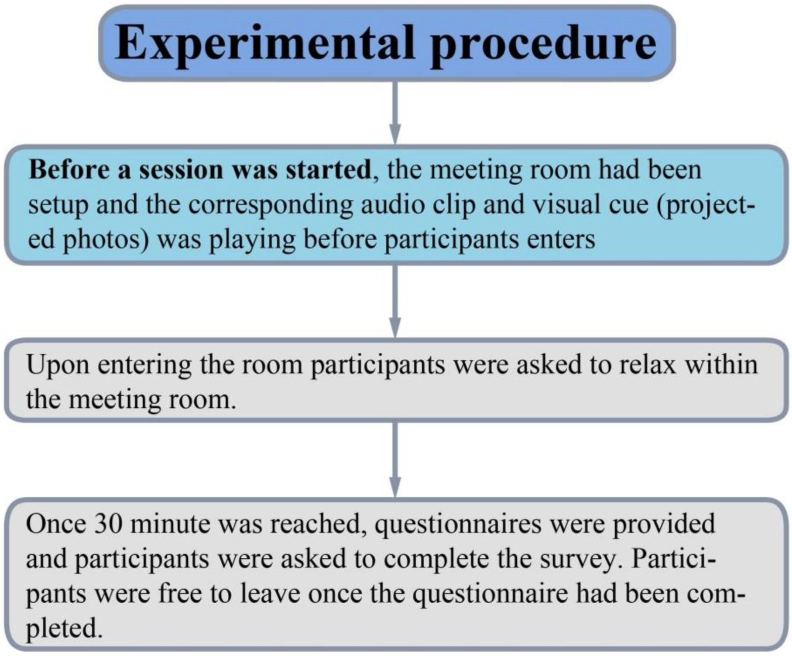

Figure 5.2 Experimental procedure

5.2.5 Data analysis

The independent variables in the analysis were divided into three environmental contexts. First, acoustic variables from the four audio clips consisted of combinations of street music, fountain sound, and traffic sound (see Section 2.1.4). Second, the visual cue consisted of the projected picture corresponding to the audio clip. The pictures were captured on an iPhone 6s at Sheffield city centre at the same site as the corresponding audio recordings. Third, the other variables consisted of the informational context, i.e. the realisation of stimuli, thoughts of participants, activity performed by participants, and gender. The informational context was identified through the open questions in the questionnaire.

The dependent variables were the six mood categories, i.e. anger, confusion, depression, fatigue, tension, and vigour from the POMS questionnaire (McNair et al., 1992). No further mood category was added to maintain the internal consistency of the questionnaire.

MANOVA was implemented as the primary statistical model for the analysis because multiple dependent variables were present in the problem (i.e. six mood states). To explore the data further, the MANOVA was followed by a discriminant analysis and factorial ANOVA (GLM 3). The advantage of using MANOVA over ANOVA was that it not only helped protect against the inflation of type I errors, but also had a greater ability to detect group differences as it considered the interaction among dependent variables. In general, only one of either ANOVA or discriminant analysis followed MANOVA. The reason for conducting both analyses in this study was the use of the independent variables (specifically, the sound stimuli).

The assumptions of MANOVA were tested (the assumptions of multivariate normality and homogeneity of covariance matrices). Multivariate normality was checked through histograms (see Figure 5.3). As shown in Figure 5.3 anger, depression, fatigue and tension scores were skewed towards the left whereas the vigour score was skewed towards the right. The histogram indicates that the data violated the normality assumption and in turn violates the multivariate normality assumption.

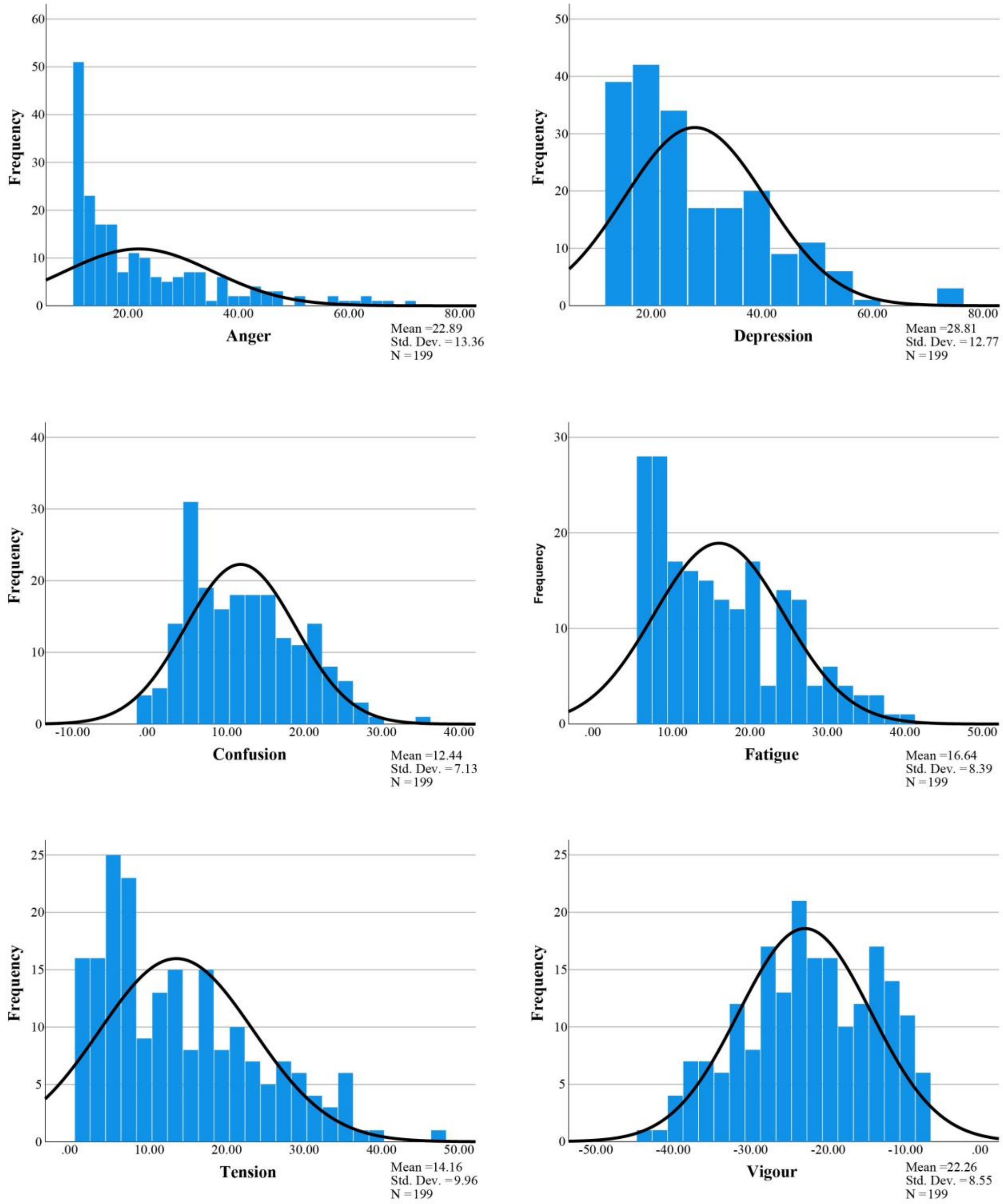

Figure 5.3 Frequency against total mood score rating histograms of six mood states.

The assumption of homogeneity of covariance matrices was tested through Levene's test (Box's test was also supposed to be conducted, however, as the group sizes were equal, Box's test is unreliable and should be disregarded). The result of Leven's test is shown in Table 5.3. The anger scores as a dependent variable violated the homogeneity of covariance matrices.

		Levene Statistic	df1	df2	Sig.
Anger	Based on Mean	4.33	15	182	0.00
	Based on Median	2.68	15	182	0.00
Confusion	Based on Mean	1.33	15	182	0.19
	Based on Median	0.83	15	182	0.64
Depression	Based on Mean	2.88	15	182	0.00
	Based on Median	1.45	15	182	0.13
Fatigue	Based on Mean	0.89	15	182	0.57
	Based on Median	0.56	15	182	0.90
Tension	Based on Mean	1.56	15	182	0.09
	Based on Median	1.03	15	182	0.42
Vigour	Based on Mean	1.19	15	182	0.29
	Based on Median	0.97	15	182	0.49

Table 5.3 Levene's test of equality of error variances tests the null hypothesis that the error variance of the dependent variable is equal across all groups

However, when group sizes are equal MANOVA is robust against the violation of normality. Similarly, when group sizes are equal Pillai-Bartlett method (of MANOVA) can also be robust against the violation of homogeneity of covariance matrices. Hence the Pillai-Bartlett method was implemented for the MANOVA.

All the sound clips consisted of multiple sound types, meaning that there was no clear comparison between the individual sound types. Discriminant analysis was useful for viewing the sound stimuli as a whole and discriminating all sound stimuli without considering individual sound types within groups. This analysis was followed by ANOVA and a *post hoc* analysis to compare the sound clip differences for each individual mood state. Overlapping between the results of the discriminant analysis and factorial ANOVA were expected; however, the factorial ANOVA and its *post hoc* test served as a detailed exploration of the results of the discriminant analysis. The sound level difference within each sound clip was examined via a simple regression. Factors that were not related to sound were analysed and filtered through a multiple regression. Figure 5.4 summarises the statistical analysis of factors and mood states.

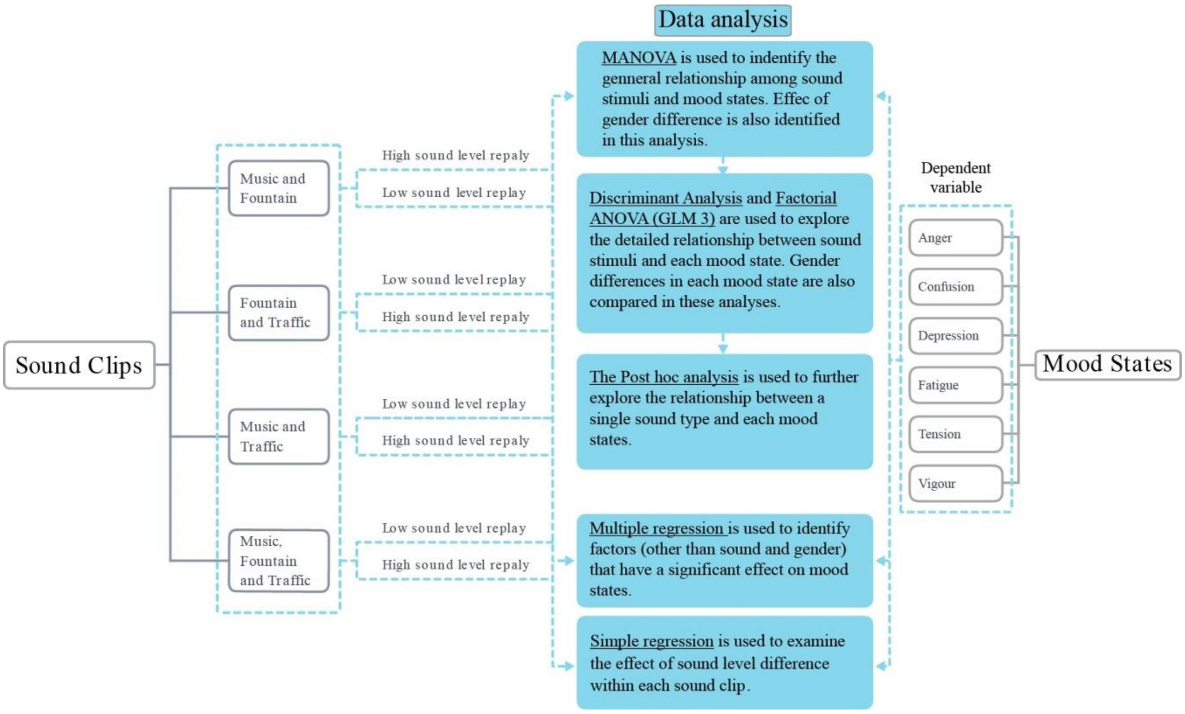

Figure 5.4 Data analysis process

5.3. Results and discussion

5.3.1. Relation between sound type and mood state

5.3.1.1. General interaction between sound type and mood

To confirm if a general effect existed between the sound clips and mood states, a MANOVA and Pillai–Bartlett trace statistic was applied. All six moods were input as dependent variables, whereas *gender, sound clips,* and *the realisation of sounds* were input as response variables. The result showed that sound clips [V = 0.33, F (18,537) = 3.70, p < 0.001], and their relationship with the gender of the subject [V = 0.17, F (18,537) = 1.75, p < 0.05] significantly affected mood states, but realisation of sound stimuli [p > 0.05] did not. The subsequent univariate test confirmed that the significant effect of sound clips existed in anger [F(3,182) = 11.29, p < 0.001, ω^2 = 0.071], confusion [F (3,182) = 7.75, p < 0.001, ω^2 = 0.046], fatigue [F (3,182) = 4.84, p < 0.01, ω^2 = 0.028], tension [F (3,182) = 12.99, p < 0.001, ω^2 = 0.081], and vigour [F (3,182) = 4.93, p < 0.01, ω^2 = 0.029] (see also Table 5.4).

Table 5.4 Multivariate tests between sound clips, notice of sound stimuli and gender difference

Effect	Value	F	Hypothesis df	Error df	Sig.
Intercept	0.876	208.168	6	177	0.000
Sound clip difference	0.331	3.698	18	537	0.000
Notice of sound stimuli	0.047	1.439	6	177	0.202
Gender difference	0.110	3.634	6	177	0.002
Sound clip difference and Notice of sound stimuli	0.081	0.824	18	537	0.672
Sound clip difference and Gender difference	0.166	1.751	18	537	0.028
Notice of sound stimuli and Gender difference	0.053	1.667	6	177	0.132
Sound clip differences, Notice of sound stimuli and Gender Difference	0.137	1.432	18	537	0.110

*** p < 0.05, ** p < 0.01, *** p < 0.001**

5.3.1.2. Discrimination of sound clips based on moods

The first step to identifying the effect of sound type on mood state involved differentiating the replayed sound clips. A discriminant analysis was conducted to segregate the sound clips into groups with respect to their interaction with the mood states. The analysis revealed *three* discriminant functions. The *first* explained 79.4% of the variance (*canonical* R^2 = 0.24), the *second* explained 14.5% of the variance (R^2 = 0.05), and the *third* only explained 6.2% of the variance (R^2 = 0.02). When combined, these discriminant functions significantly differentiated the four sound clips [$\Lambda = 0.70$, $X^2(18) = 69.33$, $p < 0.001$]. However, removing the *first* function revealed that neither the combination of the *second* and *third* functions [Λ = 0.92, $X^2(10) = 15.71$, $p > 0.05$] nor the *third* function alone [Λ = 0.98, $X^2(4) = 4.74$, $p > 0.05$] could differentiate the sound clips significantly. The correlation between moods and discriminant functions revealed that *anger* [r = 0.76], *confusion* [r = 0.62], *fatigue* [r = 0.50], and *tension* [r = 0.82] were more heavily loaded on the *first* function, *vigour* on the *second* function [r = 0.50], and *depression* on the *third* function [r = 0.53].

Based on the *group mean* comparison (indicated by '+' and '-' signs) shown in Table 5.5, the *first* function discriminated sound clip 1 (fountain sound and street music) and 3 (traffic sound and street music) from clip 2 (fountain sound and traffic sound) and 4 (fountain sound, street music, and traffic sound). This differentiation is also shown in Figure 5.5 (in Section 5.3.3 gender differences), where sound clips 1 and 3 generally scored higher than sound clips 2 and 4. The *second* function discriminated sound clips 1 and 2 from sound clips 3 and 4. The *third* function discriminated sound clips 1 and 4 from sound clips 2 and 3. To summarise, the result of the discriminant analysis revealed that *anger*, *confusion*, *fatigue*, and *tension* significantly differentiated between the groups of sound clips 1 and 3 and sound clips 2 and 4. *Vigour* insignificantly differentiated between the groups of sound clips 1 and 2 and sound clips 3 and 4. *Depression* insignificantly differentiated between the groups of sound clips 1 and 4 and sound clips 2 and 3.

Table 5.5 Non-standardised canonical discriminant functions evaluated over group means (4 sound clips)

	Functions		
Sound clips	First	Second	Third
Clip 1[a]	-0.545	0.155	-0.199
Clip 2[b]	0.373	0.309	0.146
Clip 3[c]	-0.542	-0.241	0.158
Clip 4[d]	0.728	-0.227	-0.107

a. street music and fountain sound
b. fountain sound and traffic sound
c. street music and traffic sound
d. street music, fountain sound, and traffic sound

5.3.1.3. Relation between individual sound types and moods

To explore the effect of the individual sound type, multiple one-on-one comparisons were made across sound clips. These comparisons were made in several subsequent *post hoc* analyses of the univariate test (a *factorial ANOVA*). The dependent variables were the six mood states, and factors were the sound clips, gender, and realisation of sound. The *post hoc* analysis compared the mean difference in mood scores between each sound clip group. A total of six groups of combinations of clips were compared. The results are summarised in Table 5.6.

Table 5.6 Mean difference (subtraction) of *post hoc* analysis between each sound clip group

		Clip 1 subtract Clip 2	Clip 1 subtract Clip 3	Clip 1 subtract Clip 4	Clip 2 subtract Clip 3	Clip 2 subtract Clip 4	Clip 3 subtract Clip 4
Games-Howell	Anger	-9.64**	-1.08	-12.19***	8.56**	-2.55	-11.11**
	Tension	-7.56***	-0.64	-9.59***	6.92**	-2.03	-8.95***
Bonferroni	Confusion	-3.52	-1.26	-6.40***	2.26	-2.88	-5.14**
	Depression	-6.16	-2.44	-6.06	3.72	0.10	-3.62
	Fatigue	-3.38	0.10	-5.28**	3.48	-1.90	-5.38**
	Vigour	-2.60	2.84	-2.45	5.44**	0.15	-5.29*

Clip 1: street music and fountain sound;
Clip 2: fountain sound and traffic sound;
Clip 3: street music and traffic sound;
Clip 4: street music, fountain sound, and traffic sound
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The *anger* and *tension* results concurred with the discriminant analysis. When sound clips 1 and 3 were compared with sound clips 2 and 4, a significant difference was found [$p < 0.01$]. The discriminant analysis suggested that *confusion* and *fatigue* should show a similar result to *anger* and *tension* because they were all discriminated by the first factor. The *post hoc* analysis suggested this was only partially true; only when sound clip 1 or 3 is compared with sound clip 4 were the outcomes significantly different. This result suggested that the mean score of *confusion* and *fatigue* did not differ significantly between sound clips 2 and 3 [$p >$ 0.05]. The *vigour* score showed a significant difference when sound clips 2 and 4 were compared with sound clip 3 [$p < 0.05$], and *depression* showed no significant result in any comparison [$p < 0.05$]. The results of *vigour* and *depression* did not fit the discrimination of the second and third factors; this was expected as the two factors did not significantly discriminate *depression* and *vigour*.

The design of the sound clips considered the combination of sound sources, and this design allowed a certain hypothesis to be drawn from the above results. As shown in the *post hoc* analysis, the first set of comparisons can be drawn between sound clips 1, 2, and 3 (each clip contains only two of the three sound types) and sound clip 4 (which contains all three sound types). These comparisons showed how moods changed when each sound type was removed from the combination of all three. The results indicated that most moods were significantly affected when *traffic* or *fountain sounds* were removed from the combination. However, the removal of *street music* (clip 2 vs. clip 4) did not evoke any significant changes in the mood states (Table 5.6).

The other groups of two-on-two comparisons of sound types were made among sound clips 1, 2, and 3. Three pairs of comparisons were conducted, and each pair showed mood differences when one sound type was unchanged while the other two sound types were changed. The result of the *post hoc* analysis showed a significant difference in *anger* and *tension* when *fountain* or *traffic sound* was a persistent factor. *Vigour* only showed a significant change when *traffic sound* was a persistent factor. However, when music was played continuously, no mood states were affected (Table 5.5). From the outcomes of the two groups of comparisons, the following was inferred 1) *fountain sound* significantly affected most mood states except *depression*; 2) *traffic sound* significantly affected most mood states except *depression* and *vigour*; and 3) *street music* had no significant effect on mood states. Owing to the limitation of the current sound clip design, the hypotheses would need to be further tested with a single sound-type sound-clip design.

5.3.2. Relation between sound level and mood

The effect of sound level on mood was analysed for each sound clip. The *A-weighted equivalent continuous sound level (LAeq)* was used as the unit of measurement of sound level. As each sound clip was played at two different LAeq, the effect of sound level differences was examined for each clip. The sound level difference is summarised in Table 5.7.

Table 5.7 Sound level differences between two distinct audio replays for each audio clip

	Clip 1	Clip 2	Clip 3	Clip 4
LAeq1 (dBA)	70.80	73.20	73.30	78.50
LAeq2 (dBA)	69.30	66.90	63.50	66.00
LAeq Change (dBA)	1.50	6.30	9.80	12.50
LAeq Change (dB)	5.00	4.00	-1.00	5.00

Clip 1: street music and fountain sound;
Clip 2: fountain sound and traffic sound;
Clip 3: street music and traffic sound;
Clip 4: street music, fountain sound, and traffic sound.

The simple regression analysis results revealed no significant relationship between different sound levels within sound clips 1, 3, and 4, for any mood state [$p > 0.05$]. For clip 2, two significant relationships were found in *fatigue* [R = .28, $R^2 = 0.078$, B = .28, $p < 0.05$] and *vigour* [R = .28, $R^2 = 0.081$, B = 0.29, $p < 0.05$]. The standardised *b*-value indicated that both the relationships found in clip 2 were positively correlated with the associated moods. The insignificance in the results may be attributed to insufficient SPL changes for each clip (Table 5.8). The results indicated that differences between the expected volume and actual volume of the *fountain*, *street music*, or *traffic sound* could not significantly affect mood states. However, moods were more susceptible to volume change in certain combinations of sound types.

Table 5.8 Simple regression analysis of sound level difference between sound clips

Mood states	Clip 1 R^2	Clip 1 B	Clip 2 R^2	Clip 2 B	Clip 3 R^2	Clip 3 B	Clip 4 R^2	Clip 4 B
Anger	0.066	0.257	0.035	0.188	0.002	0.043	0.003	0.053
Confusion	0.004	0.066	0.052	0.228	0.010	0.097	0.000	-0.009
Depression	0.025	0.159	0.007	0.081	0.015	0.124	0.004	-0.062
Fatigue	0.006	-0.076	0.078	0.279*	0.004	0.059	0.007	-0.083
Tension	0.051	0.226	0.050	0.224	0.011	0.107	0.001	-0.031
Vigour	0.019	-0.139	0.081	0.285*	0.023	-0.153	0.017	0.130

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Clip 1: street music and fountain sound;
Clip 2: fountain sound and traffic sound;
Clip 3: street music and traffic sound;
Clip 4: street music, fountain sound, and traffic sound.

In sound clips 1, 2 and 3, the relationships were mostly positive, indicated by the positive *b*-value, the exception being *fatigue* in sound clip 1 and *vigour* in sound clips 1 and 3 (indicated by negative *b*-values). However, in sound clip 4, most negative moods showed a negative relationship with SPL differences, the exception being *anger* [b = 0.053] and the positive mood *vigour* [b = 0.130] (Table 5.8). There were two possible causes of the results of sound clip 4. The first was a combination of more than two sound types. The second was the specific combination of three sound types. Note that among all the results, negative relations only appeared during the presence of *street music*. This could indicate that an increase in music volume could reduce the mood intensity.

There is evidence in the study of soundscape for the interaction between sound level and mood; however, the interaction varied across different sound types. For example, Jeon et al. (2010) found that the sound of a *stream* and *waves of a lake* no less than 3 dB below the masked traffic sound could increase urban sound quality in terms of preference. Falling water, however, was found to increase annoyance if combined with traffic sounds above 70 dBA

(Hong & Jeon, 2013). An increased sound level of bird song as a means to mask traffic sound (37.5 to 52.5 dBA) also showed an improvement in annoyance and pleasantness in soundscape (Hao et al., 2016). There was also evidence of physiological change in relation to sound level changes. In an electroencephalogram (EEG) study by Di et al. (2018), an increase in loudness (10-phon difference) of pure tone affected the amplitude of the β wave, known to be associated with emotion and mood arousal. These studies indicated that sound level should not be used as the sole predictor of mood; the difference in sound types should also be considered.

5.3.3. Effect of gender difference on mood states

The effect of difference in gender was demonstrated in the results of the MANOVA analysis, where both the *gender* of the subject [$V = 0.11$, F (6,177) = 3.63, $p < 0.01$] as well as its interaction with the sound clips [$V = 0.17$, F (18,537) = 1.75, $p < 0.05$] had a significant influence on the mood score. However, neither *the realisation of sound* nor its interaction with sound clips showed a significant effect on the mood state [$p > 0.05$]. The subsequent univariate test further confirmed that the gender difference significantly affected *anger* [F (1,182) = 7.72, $p < 0.01$, $\omega^2 = 0.015$], *confusion* [F (1,182) = 13.16, $p < 0.001$, $\omega^2 = 0.028$], *depression* [F (1,182) = 10.96, $p < 0.01$, $\omega^2 = 0.024$], and *tension* [F (1,182) = 4.89, $p < 0.05$, $\omega^2 = 0.009$].

However, because univariate tests do not consider the correlations among dependent variables (mood states), the test could not detect any interaction between the gender of the subject and the sound clips, resulting in an insignificant effect of the interaction [$p > 0.05$]. The results indicated the presence of general effects of sound clips on mood states, and that these effects could be influenced by gender difference. The effect of gender difference is also shown in Figure 5.5. Men, in general, scored a higher maximum score and had a greater range of mood scores in most mood states (*anger*, *confusion*, *depression*, *fatigue*, and *tension*), the exception being *vigour*, in which women scored equal or higher. However, fatigue and vigour which had no significant interaction with gender should not be considered as meaningful findings. In sound clip 2, the female mood score, specifically for anger, depression and tension appeared to have a greater maximum score and score range compared to males, suggesting that the combination of traffic and fountain sounds were perceived differently between genders. These results indicated that females, in general, had a higher tolerance to negative emotions (i.e. anger, confusion, depression and tension), but beyond a certain threshold, females were more likely to be affected by them (i.e. anger, depression and tension). Note that *vigour* had an inverse score compared to the other moods.

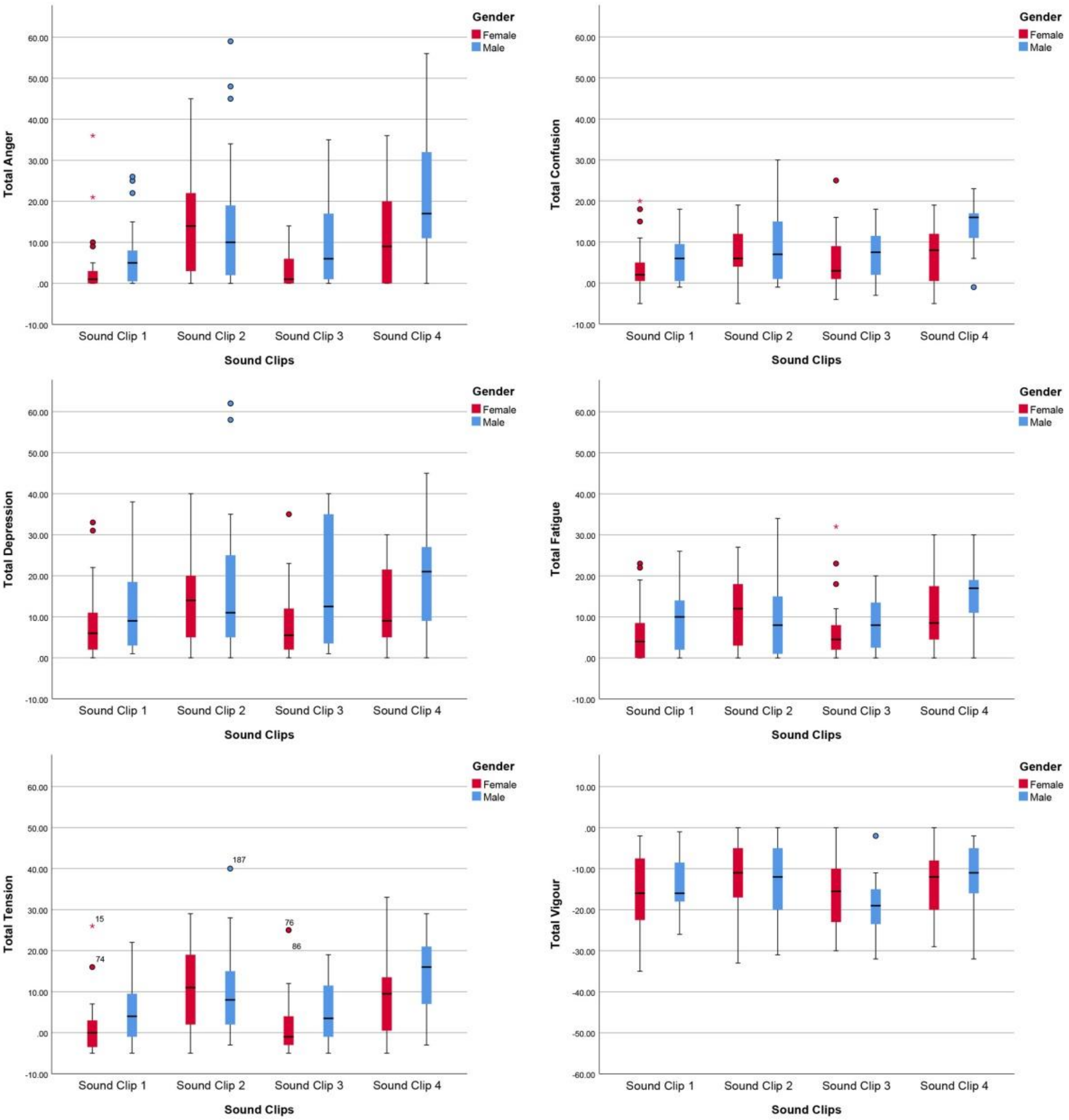

Figure 5.5 Gender difference corresponding to mood states

It is worth pointing out here the insignificant results for fatigue and vigour. The insignificant results indicated that cognitive resources spent to appraise the acoustic stimuli were not significantly different between genders. As the experiment was designed with a focus on sound types rather than gender difference, the effect of gender difference on individual emotions also needs further exploration in the terms of experiment design (such as separate male and female group into different audio replay sessions).

5.3.4. Effect of environmental context on mood state

Three contexts were identified and examined based on qualitative data. The first context was the description or mention of *logic-intensive activity* performed by participants during the experiment (this included playing on smartphones, playing poker, and reading). The second context was the *physical environment* (i.e. visible context of the laboratory outside the primary studied variables). The third context was the *thoughts of participants* beyond the experiments. A multiple regression was conducted with the three contexts input as independent variables and coded '0' for 'not realised' and '1' for 'realised' by participants. Reverse entry was implemented to eliminate the least effective contexts.

The results showed that the *physical environment* had the most significant effect among the three (Table 5.9). The power of the statistical model was also guaranteed by the power calculation (see section 5.2.2) where the significant results were protected from type I error. In all three regression models, the *physical environment* mostly showed a negative statistical significance [$p < 0.05$], indicating that the physical environment in the study reduced emotional responses. The exception was *fatigue* in the first model [$p > 0.05$]. This exception was due to the presence of the other two contexts reflected in the second and the third models, where a significant change appeared when the *physical environment* was removed. Overall, all three contexts showed a negative relation with the studied mood states. This negativity could be the result of the contexts having an indirect relation with the mood state; the contexts distracted the participants from focusing on themselves, thereby reducing the mood scores. The removal of the *logic-intensive activity* and *participants' thoughts* contexts had a small effect on the effect size (represented by the ΔR^2 value). The significance and size of the effect suggested that the *physical environment* affected mood states.

Table 5.9

Multiple regression analysis of environmental contexts (other than sound)

		Anger		Confusion		Depression		Fatigue		Tension		Vigour	
		β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2
First model	(Constant)												
	thoughts of Participants	-0.060	0.045	0.035	0.036	0.030	0.033	-0.028	0.032	-0.078	0.049	-0.097	0.051
	logic-intensive activity	0.000		-0.124		-0.054		-0.097		-0.058		-0.069	
	physical environments	-0.193**		-0.163*		-0.182*		-0.141		-0.182*		-0.169*	
Second model	(Constant)												
	thoughts of participants	-0.059	< 0.001	-0.114	-0.001	-0.046	-0.001	-0.105	-0.001	-0.095	-0.003	-0.116	-0.004
	physical environments	-0.193**		-0.155*		-0.176*		-0.147*		-0.175*		-0.161*	
Third model	(Constant)		-0.003		-0.013		-0.002		-0.011		-0.009		-0.013
	physical environments	-0.205**		-0.149*		-0.173*		-0.141*		-0.194**		-0.185**	

*** p < 0.05, ** p < 0.01, *** p < 0.001**

That personal interpretation influences the outcome of the mood state is not an uncommon occurrence in soundscape studies. Several studies have shown that visual stimuli are closely related to acoustic stimuli (Gifford & Fan, 1982; Pheasant, Horoshenkov, Watts & Barrett, 2008; Pheasant et al., 2010; Rimell, Mansfield & Hands, 2008). According to Pheasant et al. (2008), visual stimuli had a stronger effect on the pleasure rating of an environment than acoustic stimuli. Studies have also indicated that the information provided by the stimuli regarding an environment influenced people's mood and perceptions. For example, Kaplan and Kaplan (1989) suggested that the visual indication of landmarks could induce feelings of ease and comfort in people owing to the spatial orientation information. As for acoustic stimuli, Mackrill et al. (2013) found that when sound source information was included in the acoustic stimuli, participants' emotional cognition showed a positive increase.

In this study, the physical environment of the laboratory may have been interpreted differently based on the individual differences between the participants. Thus, the information extracted varied with the subject. This difference may have influenced the participants' interpretation of their own moods (Robinson, 2005). As the contexts of the physical environment were all reported through verbal (writing) exercises, this indicated the existence of consciousness through processes and the spending of cognitive resources. This not only explained the significant result in vigour but also indicated that the processes of appraising the physical environment were performed explicitly. All contexts within the physical environment may also have contributed to confusion and tension due to the laboratory setting. As the connection between the physical environment (laboratory) and the stimuli (sound clips) may not have been apparent, this could lead to confusion regarding the purpose of the experiment and may further result in stress. This was also evidenced by the reporting of confusion of the experimental purpose in the qualitative data (N=18)(this will be discussed later in Section 5.4.1.2).

Four specific contexts were identified in the physical environment: artificial lighting; observation of others; projected pictures; and observation of the room settings. In the open questions, participants claimed that the bright light from the room was uncomfortable and attracted their attention (N=10). The claim of discomfort indicates goal incongruence and potential attack of an individual's well-being (visual comfort). This potential attack was most likely to be blamed on experimenters. The above appraisal pattern was unique to anger emotion and may partially explain why the anger score was significantly affected by the physical environment.

The cases where people claimed to have observed others' activities and behaviours were all social activities such as chatting and playing cards. The obviation of social activity could have an appraisal of other's behaviour, and this could lead to potential confusion, annoyance (mild anger) and/or tension. If confusion was produced, it was likely that other's activities were perceived as inappropriate to the experiment, and created a confusing situation where the individual was confused about how he/she should behave during the experiment. If annoyance was produced, others' actions were perceived as inappropriate (goal relevance and incongruence) and the observer may have considered this as an insult to their personal values (insult to ego identity and others are to blame). This implied that the observers think others should not behave this way and contradict what he/she believed, that one should behave in an experiment setting. Tension (anxiety) could also be produced under the appraisal pattern of annoyance as it only required goal relevance and goal incongruence. In the same situation explained in annoyance, the observer's meaning structure was being threatened, and he/she was uncertain whether this threat was true or not. This appraisal accurately explained the core relational theme of anxiety, namely the uncertain existential threat.

Conversely, if the social activity was not perceived as inappropriate, the activities could be ignored or perceived positively and may result in a relaxing experience, as social interaction has been known to produce a positive effect (McIntyre, Watson, Clark & Cross, 1991). This positive experience may lead to the recovery of cognitive resources, which was supported by the significant result in vigour.

The projected pictures (N=12) and observation of the room settings (N=7) were all part of the visual context that has been reported to attract the attention of participants. In terms of information contained, the two contexts may provide conflicting information. The projected pictures are related to the sound clip that was being played and provide a visual cue and immersive outdoor experience for the stimuli. The room setting, on the other hand, contained information about the indoor environment and suggested a laboratory environment. Therefore the two contexts may have contributed to confusion mood states. However, it was unlikely that these two contexts contributed to anger due to there being no others to blame.

5.3.5 Analysis of underlying components

5.3.5 Analysis of underlying components

The items in POMS were tested with principal component analysis (PCA), and the resulting components were compared against the original 6 mood states proposed by the original POMS to verify the validity of the study results.

A PCA was conducted on 65 items with oblique rotation (promax, kappa = 4)). The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) = .92 indicating the data were adequate for PCA (Kaiser (1974), recommends a bare minimum KMO value of 0.5 for the sample to be adequate). Bartlett’s test of sphericity X2 (2080) = 10534.23, p < .001 indicated a correlation between items was sufficient for PCA. 12 components were discovered based on the Kaiser's criterion with eigenvalues above 1. In combination, 13 components explained a total variance of 71.64% (see also Table 5.10).

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	24.65	37.93	37.93	24.65	37.93	37.93	21.15
2	7.07	10.87	48.80	7.07	10.87	48.80	19.40
3	2.79	4.28	53.09	2.79	4.28	53.09	11.45
4	1.99	3.06	56.15	1.99	3.06	56.15	9.73
5	1.75	2.69	58.83	1.75	2.69	58.83	12.35
6	1.40	2.15	60.98	1.40	2.15	60.98	13.02
7	1.33	2.04	63.03	1.33	2.04	63.03	3.91
8	1.25	1.93	64.95	1.25	1.93	64.95	3.74
9	1.20	1.85	66.80	1.20	1.85	66.80	3.69
10	1.07	1.65	68.45	1.07	1.65	68.45	1.41
11	1.05	1.62	70.08	1.05	1.62	70.08	3.80
12	1.01	1.56	71.64	1.01	1.56	71.64	2.15

Table 5.10 Total variance explained. Initial analysis based on eigenvalues, only showing components with eigenvalues above 1 (Kaiser's criterion)

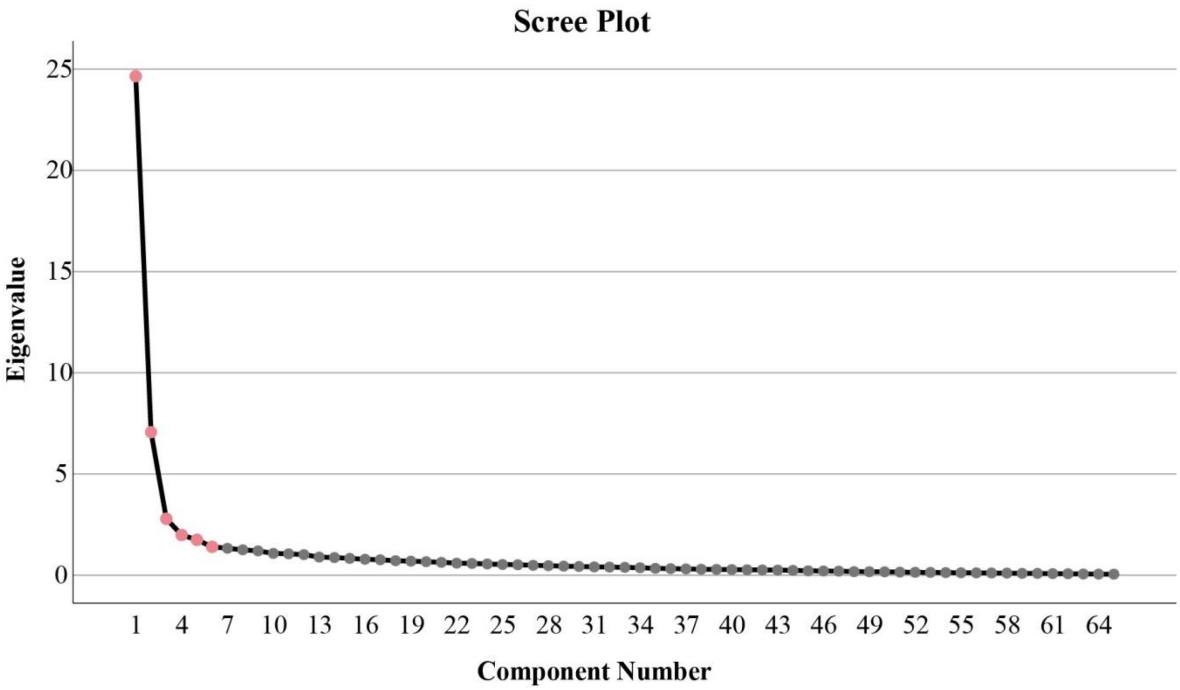

Figure 5.6 Scree plot of eigenvalue against components

The scree plot (Figure 5.6) shows the point of inflexion is at the 6th component. Based on both eigenvalues and scree plot, keeping both 6 and 12 components is justified. Although keeping 6 components is similar to POMS' original categorisation (the 6 mood states), all 12 components were examined.

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
Furious	1.15											
Rebellious	1.01											
Resentful	0.97											
Bitter	0.92											
Bad-tempered	0.92											
Angry	0.88											0.59
Ready to fight	0.87											
Peeved	0.73											
Spiteful	0.66											
Deceived	0.65											
Grouchy	0.64											
Weary	0.63											
Terrified	0.56											
Unhappy	0.55											
Annoyed	0.54	0.47										
Friendly	-0.41											
Forgetful*	—											
Exhausted		0.90										
Sluggish		0.89										
Fatigued		0.85										
Listless		0.74										
Muddled		0.65										
Unable to concentrate		0.63										
Anxious		0.60										
Worn out		0.56										
Blue		0.53										
Uneasy	0.40	0.49										
Discouraged		0.47										
Nervous		0.43										
Restless		0.43										
Gloomy		0.41										
Activity			0.98									
Energetic			0.90									
Cheerful			0.79									
Full of pep			0.76									

Lively			0.73									
Vigorous			0.69									
Relaxed			-0.57									
Trusting			0.51									
Sorry for things done				0.93								
Lonely		0.48		0.65								
Sad				0.61								
Guilty				0.60								
Worthless				0.46								
Helpless				0.45								
Miserable				0.41								
On edge					0.81							
Panicky					0.77							
Confused						1.10						
Bewildered						0.79						
Alert*	—											
Sympathetic							0.93					
Helpful							0.58					
Efficient			-0.42				-0.56					
Desperate							0.48					
Good natured								1.01				
Carefree								0.59				
Unworthy									0.80			
Shaky									0.43			
Uncertain about things										0.71		
Bushed		0.45								0.57		
Clear headed			0.41								-0.83	
Hopeless*	—											
Tense												0.45
Considerate												0.40

Table 5.11 pattern matrix of unique factor loadings after factor rotations in the orders contain the most items to the least items
* unique factor loading below 0.4

Table 5.11 shows the unique factor loading for all items in relation to the 12 components after factor rotation. The components and their underlying theme based on the items they were contained are as follow: 1) Anger (12 anger items with 5 non-anger items), 2) exertion of cognitive resource (6 fatigue items, 4 tension items 4 depression items, and 2 confusion items, and 1 anger item), 3) vigour (6 vigour items and 4 non-vigour items), 4) depression (7 depression items), 5) tension (2 tension items), 6) confusion (2 confusion items), 7) tension (2 non-tension items that contain the aspect of feeling under pressure), 8) friendly (1 friendly item and 1 vigour item), 9) emotional distress (1 tension item and 1 depression item), 10) confusion (1 confusion item and 1 fatigue item), 11) confusion (1 confusion item), 12) 3 ambiguous items that cannot be reasonably labelled. (See also Table 5.12).

Components	1	2				3	4	5	6	7	8	9	10	11	12
Items (emotional related words)	Furious	Exhausted				Activity	Sorry for things done	On edge	Confused		Good-natured	Shaky	Uncertain about things	Clear-headed*	
	Rebellious	Sluggish				Energetic	Lonely*	Panicky	Bewildered						
	Resentful	Fatigued				Full of pep	Sad								
	Bitter	Listless				Lively	Guilty								
	Bad-tempered	Bushed*				Vigorous	Worthless								
	Angry*	Worn-out				Efficient*	Helpless								
	Ready to fight		Anxious				Miserable								
	Peeved		Uneasy*												
	Spiteful		Nervous												
	Deceived		Restless												
	Grouchy			Blue											
	Annoyed*			Discouraged											
				Gloomy											
				Lonely*											
					Muddled										
					Unable to concentrate										
Distinctive emotion	Anger	Fatigue	Tension	Depression	Confusion	Vigour	Depression	Tension	Confusion	Tension	Friendliness	emotional distress	Confusion	Confusion	—
Numbers of items related to the emotion	12	6	4	4	2	6	7	2	2	—	1	1	1	1	—
Items did not fit the mood states categories	Weary	Annoyed				Relaxed				Efficient*	Carefree	Unworthy	Bushed*		Tense
	Terrified					Trusting				Desperate					Considerate
	Unhappy					Clear-headed*									Angry*
	Friendly					Cheerful									
	Uneasy*														

* items that shared between two components

Table 5.12 list of items attributed to each component and the underlying mood state that represented each component

As shown in Table 5.12, to include all 6 mood states proposed by POMS at least the first 6 components from PCA are required. Regarding these 6 components, component 2 contained items from 4 different mood states, they are: 6 fatigue items, 4 tension items, 4 depression items and 2 confusion items. At least 3 of the 4 mood states (fatigue, tension, and depression) need to be considered as the numbers of items included were relatively large and cannot be ignored. However, the inclusion of multiple mood states in component 2 indicates the component does not measure specific emotions, but rather common themes shared by these mood states. In the case of component 2, the common themes shared by items were: an unpleasant appraisal of the environment (shared by tension, and depression, see also sections 3.4.2 and 3.4.4), and the expenditure of cognitive resources (as any conscious emotional response does, see section 3.4.5).

Among the first 6 components, depression (in components 2 and 4), tension (in components 2 and 5) and confusion (in components 2 and 6) mood states were split between two of the six components, suggesting there were underlying sub-themes within each of these three mood states. Based on the items and the attribution to the components it is unclear what the cause of such a split was. Hence the only conclusion that can be drawn was whether these emotional states were valid when they were interpreted as individual mood states. For depression, as the majority of the items were attributed to component 4 (7 items out of 11), it was determined reasonable to include the full appraisal pattern (an appraisal components combination unique to each distinctive emotion, see also the explanation in section 3.4.4) of the emotions. For tension, the majority of the items were attributed to component 2 (4 out of 6 components) and the two items attributed to component 5 were too few to be themed with certainty. Therefore only, the appraisal of an unpleasant environment and spending of the cognitive resource should be interpreted. For confusion, both components (components 2 and 6) contain too few confusion items (2 items each), in addition, confusion items also appear in components 10 and 11 (each containing 1). The separation of confusion was too scattered, and the underlying theme of each component was too ambiguous to define making any interpretation of the confusion mood states unlikely to be accurate. Beyond the first 6 components, components 7 to 10 all contained too small a number of items or few items with mixed mood states without apparent connection. It was determined that components 7, 8, 9 and 10 should be ignored.

Some items were attributed to components that did not contribute to the identification of the underlying theme (see row 'Items did not fit the mood states categories' in Table 5.12). The false attribution of these items could be the result of participants misunderstanding the items caused by ambiguous words or meaning lost in translation. Alternatively, lack of attention during the survey session could also cause such miss attribution. However, the items that were misattributed were relatively small in number and less likely to cause a significant difference in the final results.

In summary, the interpretation of the data results based on POMS' categorisation (i.e. the 6 mood states) was valid but 'tension' should be interpreted with a caveat. The only mood state that was not reasonable to interpret was that of 'confusion'.

5.4. Discussion

5.4.1 Appraisal processes of each mood category

Before assessing the appraisal process of each mood category the goals of the participants should be clarified. Despite no detailed information being given to the participants, the experiment conductor did ask participants to relax in the laboratory so they could absorb the stimuli naturally. Therefore it was safe to assume participants' primary goals and activities engaged during the experiment was aimed at relaxing. According to the qualitative data only about a quarter (N=53) of the participants noticed and paid explicit attention to the sound clips, indicating that most of the emotional processes was preceded implicitly. This proportion provided evidence for the assumption made in the methodology (Chapter 3), that the acoustic environment would be appraised implicitly most of the time.

The sound clips were referred to extensively in the following paragraphs, and each clip was referred to the specific combination between street music, fountain sound and traffic sound as explained in Section 5.2.2. To provide clarity, the list of sound clips and their sound combinations were as follows:

Clip 1: street music and fountain sound;
Clip 2: fountain sound and traffic sound;
Clip 3: street music and traffic sound;
Clip 4: street music, fountain sound, and traffic sound.

5.4.1.1 Anger

As the result of the univariate test of MANOVA showed, anger was significantly different among the sound clips, indicating that different combinations of *street music*, *traffic sound* and *fountain sound* could indeed affect anger as an emotion. If this effect was produced through emotional memory (implicit process), this indicated that this past experience was quite universal among participants based on both the significant result and the number of participants that implicitly appraised the acoustic stimuli. It could be safely assumed that some of the three sound types were inherently perceived as annoying or anger (this proves to be traffic sound and fountain sound in the post-hoc test). There was also a possibility where some of the sound types could relate to a traumatic experience, however, this was unlikely to be universal enough to produce any significant result. The qualitative data did indicate that there was a relatively small portion of participants who appraised the acoustic stimuli consciously. If this was indeed the case, some of the sound clips were perceived as the interference of the goal of relaxation. Some of the sound clips could have been interpreted as intentionally placed by the experimenters to hinder the relaxation activity or environment. Notably, the anger baseline could also be influenced by the experiment design itself despite it not influencing the experiment outcomes. As the experimenter intentionally hide the detailed information of the experiment from participants, the design itself could have been interpreted as an act of distrust toward the participants, hence anger could be produced as this action could be seen as a slight to their personal values.

The discriminant functional analysis showed a difference in anger score that separated street music from traffic sound and fountain sound combined through the first discriminant function. The first group of the post-hoc test results (see Table 5.6) showed that the mean score of the anger mood differed significantly between sound clip 1 and clip 2 (produce negative value when the mean score of clip 1 minus clip 2), and clip 2 and clip 3 (produce negative value when the mean score of clip 2 minus clip 3) but showed no significant difference between sound clip 1 and clip 3. These results meant that street music was the sound that had a lower anger score, and fountain sound and traffic sound had a higher anger score but did not differ significantly. This difference between the three sound types indicated whether street music could reduce/distract attention from the anger emotion, or where the traffic sound and fountain sound were likely to be appraised as an attack of ego-identity or trigger emotional memory related to an anger outcome. The second groups of post-hoc test results showed that anger scores differed significantly between clip 1 and clip 4 (produce negative value when the mean score of clip 1 minus clip 4), clip 3 and clip 4 (produce negative value when the mean score of clip 3 minus clip 4). However, there was no significant difference between clip 2 and clip 4. These results showed that adding ether traffic sound or fountain sound into the acoustic environment would increase the anger score but adding street music alone did not affect the anger score.

By concluding the results of the statistical and qualitative data, this study confirmed that among the sound clips, traffic sound and fountain sound were the cause of increases in the anger scores. Traffic sound did so, likely because the socially accepted idea of the negative influence associated with traffic has been accepted as a universal angering emotional memory. For the fountain sound, it was likely that the loud static noise was inherently annoying. Street music, however, was unlikely to affect the anger emotion.

5.4.1.2 Confusion

As the result of the univariate test of MANOVA showed, confusion was significantly affected by sound clip differences, indicating that the combinations among street music, traffic sound and fountain sound could be difficult to understand according to the context that the participants had faced during the experiments. This difficulty in comprehension also implied that, at the moment of the confusion, the participant could not form emotions as the foundation of emotion: the person-environment relationship could not be established. If participants dismissed the situation and gave up in understanding the sound clips, this could result in a later unconscious implicit reaction to the sound clips, and emotion may be produced based on the emotional memory associated with the sound clips. If the participants decided to put in more effort to try to contextualise the sound clips, emotion may also be produced through a conscious explicit process requiring participants to commit cognitive resources. Additionally, as the vigour and fatigue mood scores were significantly different among sound clips, this meant that the spending of cognitive resources did differ among sound clips. This difference in cognitive resources also indicated a possibility that the initial confusing participants committed effort to understand the sound clips. The confusion itself was not an emotion and no specific emotions were associated with the confusion state (see the discussion in Section 3.4.3). The only prediction that could be made was whether the stimuli was easy to understand and potentially increase the cognitive resource cost to appraise the stimuli. In the qualitative data, 18 participants reported having difficulty to concentrate and/or did not understand the purpose of the experiments.

The discriminant functional analysis showed a significant difference in confusion scores and differentiated street music from the combination of traffic and fountain sounds through the first discriminant function. The post-hoc test result (see Table 5.6) showed that confusion scores differed significantly between sound clip 1 and clip 4 (produce negative value when the mean score of clip 1 minus clip 4), and sound clip 3 and clip 4 (produce negative value when the mean score of clip 3 minus clip 4). However, there was no significant difference in confusion between sound clip 2 and clip 4. The results of the statistical analysis and qualitative data suggested that the traffic sound and fountain sound were sound types that likely caused a confusing situation. The confusion was most likely the result of the fact that participants were not able to interpret how the two sounds fit into the context of the experiments. The increase in confusion also caused the cognitive resource cost to appraise an acoustic environment to increase and, in turn, resulted in mental fatigue if people ever chose to appraise such an environment. Street music did not appear to have any significant impact on confusion scores, indicating that the addition of street music in an acoustic environment was unlikely to confuse people or create conflicting environmental information between the music itself and the environment.

5.4.1.3 Depression

No significant relationship was found between sound clips and depression mood categories. The insignificance indicated that street music, traffic sound and fountain sound were unlikely to cause depression-related emotions (i.e. sadness, fear or guilt) through a conscious appraisal. For unconscious implicit ways, although there was the possibility that depressive emotions could trigger through related emotional memories, the insignificant result indicated that there were no universal ideas or values that associated the three sound types and depressive emotions.

5.4.1.4 Tension (Anxiety)

The univariate test of MANOVA shows that tension was significantly affected by the sound clips. This result indicated tension as a mood category that could be affected by combinations of street music, traffic sound and fountain sound. Tension as an emotion only consisted of goal relevance and goal incongruence as appraisal patterns, since all negative emotion requires these two appraisal components as the foundation, thus tension would almost certainly be present in the forming of negative emotions. This company of tension with other negative emotions should not only apply to the conscious appraisal process but also the unconscious emotional responses triggered through emotional memories. As emotional memory is a memory of past conscious appraisal processes that trigger related emotion automatically, this indicated that the memory itself also included tension due to the appraisal pattern that existed at the forming of the memory. In this study, the only difference that could be detected by statistical analysis in the tension mood categories was goal incongruence.

The discriminant functional analysis showed a difference in tension scores that discriminated sound clip 1 and clip 3 from sound clip 2 and clip 4 through the first discriminant function. The major difference between tension score was between street music and the fountain and traffic sound combination. The post-hoc test (see Table 5.6) showed that the tension score differed significantly between: (1) sound clip 1 and clip 2 (produce negative value when the mean score of clip 1 minus clip 2); (2) sound clip 2 and clip 3 (produce positive value when the mean score of clip 2 minus clip 3); (3) sound clip 1 and clip 4 (produce negative value when the mean score of clip 1 minus clip 4); and (4) sound clip 3 and clip 2 (produce negative value when the mean score of clip 3 minus clip 4). Whereas between sound clip 2 and clip 4 there was no significant difference found in tension. The combination of the series of statistical analyses has therefore indicated that traffic sound and fountain sound were more likely to be appraised as goal incongruence during relaxation and that street music was unlikely to be appraised as goal incongruence in the acoustic environment during relaxation. This conclusion was supported by the results from the anger mood categories as anger also contained appraisal patterns of tension.

5.4.1.5 Fatigue

The univariate test of MANOVA showed that fatigue scores differed significantly among sound clips, indicating that combinations of street music, traffic sound and fountain sound could affect fatigue as mood states. As previously discussed fatigue is not an emotion (see Chapter 3.4.5), rather it explains a condition where the cognitive resource required to appraise an environment has exceeded the cognitive resource that an individual possesses. Under the state of fatigue, people are more likely to feel stress (tension), hence more likely to respond with negative emotions. The change of fatigue score in this study indicated a change in the balance between cognitive resource spent and its requirement without reversing the balance completely. There was no distinction between cognitive explicit emotional process and unconscious implicit emotion process in fatigue. This was not only due to fatigue not being an emotion, but also because that any appraisal process that caused the fatigue to appear already implied the existence of a conscious cognitive process, since fatigue was a result of the over spending of cognitive resources and pending of cognitive resource is a conscious act.

Discriminant functional analysis showed a difference in fatigue scores and differentiated street music from fountain sound and traffic sound through the first discriminant function. The post-hoc test showed that the fatigue scores differed significantly between sound clip 1 and clip 4 (produce negative value when the mean score of clip 1 minus clip 4) and between sound clip 3 and clip 4 (produce negative value when the mean score of clip 3 minus clip 4). No significant difference in fatigue was found between sound clips 2 and clip 4. The results of all statistical analysis indicated that traffic sound and fountain sound both caused an increase in participants' cognitive resource spending under the fatigue state. Street music, however, had no significant contribution to the cognitive resource spending of participants.

5.4.1.6 Vigour

The univariate test of MANOVA showed a significant relationship between vigour and sound clips, indicating that vigour state could be affected by street music, fountain sound and traffic sound. Similar to fatigue, vigour mood is not an emotion (see Chapter 3.4.5), rather it explains a state opposite to that of fatigue. In the vigour state, the cognitive resource required to appraise an environment has not exceeded the cognitive resource possessed by an individual. Similar to the fatigue state, a change of vigour score also indicated a balance between cognitive resource spent and the requirement of an environment without reversing the balance completely. In the vigour state, people were less likely to experience negative emotion when facing challenging environmental encounters. If an individual's vigour score changed, it also implied that a conscious explicit emotional process had taken place, despite his/her cognitive resource not being depleted.

The discriminant functional analysis showed a difference in vigour score that separated fountain sound from street music and traffic sound through the second discriminant function. The second function explained 14.5% of variant, significantly less than the first function which explained 79.4% of the variants, indicating that the change in vigour, although significant, was not as intense compared to other mood categories. The post-hoc test showed a score difference between sound clip 2 and clip 3 (produce positive value when the mean score of clip 2 minus clip 3) and between sound clip 3 and clip 4 (produce negative value when the mean score of clip 3 minus clip 4), but no significant difference in vigour was found between sound clip 1 and clip 4 or between sound clip 2 and clip 4. The statistical analyses indicated that in a vigour state, fountain sound could reduce the cognitive resource requirement to appraise an environment (or the cognitive resource spent). The street music and the traffic sound did not significantly affect the spending of the cognitive resource. These results differed from the participants in the fatigue state, providing evidence that in, the vigour state, people could deal with encounters more easily as they spent less cognitive resource in appraising the environment. The result also showed that acoustic stimuli affected cognitive energy spent/requirement differently in terms of their effect on the cognitive resource between the fatigue and vigour states.

5.4.2 Verbal expression

The verbal expression of mood was recorded via the open questions. The two identified mood states were *annoyance* (28 cases), where participants described themselves as ‘annoyed’ or described the sound stimuli as ‘noise’; and *confusion* (18 cases), where participants expressed their inability to focus, their confusion about the purpose of the experiment, or confusion in general. In the case of participants providing a verbal expression of the two moods, the scores of correlated words were examined. The results indicated that, in most cases, when a verbal expression of the mood was made, the correlated word for the mood also had a score of above 0. However, these scores varied with participant. This difference in scores suggested that verbal expression could represent the change of mood but not its intensity. The data also indicated that many participants with high *confusion* or *annoyance* scores had no verbal expression for the two moods, suggesting that, when given no instruction, mood was not always expressed verbally.

The open questions also indicated that 95 participants described their realisation of the sound stimuli. Music (37 participants) appeared to attract the most attention, followed by traffic (16 participants), and fountain sounds (6 participants). Seven participants also noticed that the sound stimuli were digitally edited. There were 23 participants who mentioned that they noticed the sound but did not explain what aspects of the stimuli drew their attention. Overall, the verbal expression of sound stimuli did not affect the mood states (see Table 5.4).

5.4.3 Limitations

In a previous study (Swaminathan & Schellenberg, 2015), *street music* appeared to have a significant effect on the mood state '(see discussion between results and existing literature in section 7.1.1). However, this study revealed contradicting results. This could be the result of the absence of an actual performer, leading to a reduction in eventfulness in a laboratory context. As indicated by the qualitative data, the physical setting of the environment could significantly affect the mood state.

In this study, sound clips were designed with a combination of sound types. Therefore, the design limited the investigation of individual sound types. Single sound types could not be segregated and played for different participant groups for data analysis. Hence, the interpretations of the results were only for sound combinations, implying that these interpretations required a different experimental design for a thorough examination. This should be considered in future studies.

There are many different sound sources within each sound type category. This study only recorded a single source for each studied sound type because sound types, in general, have similar effects on human perception. This can be seen in studies of nature sounds (Ekman et al., 2015) and traffic sounds (Hao et al., 2016). However, certain sound sources within a sound category may have a different effect on perception than other sounds. This difference is especially true for music. Music is known to elicit different moods depending on the musical composition (Robinson, 2005), and the characteristics of each piece of music are different and should be viewed separately. As another example, different water sounds would have different effects in masking background sounds (Jeon, et al., 2010), and the sound of a fast flowing fountain could cause unpleasantness compared with the usual pleasant perception of water sound (Ekman et al., 2015). It is also important to note that the water sounds used in this study fit the category of the sound of a fast flowing fountain, and the outcome indicated an association with higher negative mood scores.

5.4.4 Application

This study signified the importance of an on-site survey when considering using acoustic designs to improve the mood state of people in an urban public setting, specifically considering the types of sound present in the existing context. The combinations of sound types appeared to have a more important role in the acoustic design of public spaces in terms of altering mood states. This importance was reflected by the results, demonstrating that significant mood changes in relation to the combination of sound types and sound intensity. Moreover, despite the importance of identifying the effect of a single sound type, the effect changed when combined with other sounds. Existing studies provided results for certain combinations of sound types. However, further studies are required to explore different sound types and mood states for the application to be effective.

5.5 Conclusions

The current study examined the relationship between the type of sound and the mood state of a person in the context of soundscape. Three sound types (*street music*, *fountain sound,* and *traffic sound*) and their effects on six moods (*anger, confusion*, *depression*, *fatigue*, *tension,* and *vigour*) were studied.

The results suggested that the types of sound had a significant effect on the mood state. Among the studied moods and sound types, *anger* and *tension* were altered by most of the sound type combinations (significant in four out of six comparisons). Confusion, fatigue, and vigour were affected by a small number of sound type combinations (significant in two out of six comparisons) (Table 5.6). Depression did not appear to be affected by any combination. Several hypotheses regarding single sound types were formulated, based on the results. Among the studied mood states: 1) most moods except depression were affected by fountain sound; 2) anger, confusion, fatigue, and tension were significantly influenced by traffic sound; and 3) no mood was significantly affected by street music. These results indicated that the effect of sound type on the mood state varied with the sound type and combination.

Overall, the difference in sound level between the actual environment and the expectation of subjects did not show a significant impact. However, different combinations of sound types indicated that there were exceptions. For example, the combination of *fountain* and *traffic sounds* appeared to significantly affect *fatigue* and *vigour* despite small sound level differences. This result indicated that difference in sound levels have an impact on the mood outcome, but the effect may vary in intensity depending on the sound type or combination of sound types.

Differences in gender appeared to have a significant effect on the relationship between sound type and the person’s mood. Women may be more resilient to negative mood states and more susceptible to positive mood states than men. However, this difference was sometimes reversed when considering specific types of sound and mood categories. The study also provided additional findings that may inspire further studies. These findings suggested that the noticing of sound stimuli had no significant effect on the mood state or its interaction with different sound clips, and environmental context (visual) could significantly affect the mood states.

In summary, the significant relationship between sound type and mood state were identified and explored in this study. More importantly, all the results indicated that the mood outcomes varied across mood categories. This signified the need to study the mood/emotional aspects of soundscape in a categorical manner.

This study also focused on the sound types' effect on distinctive emotional responses. Context was also found to have a significant effect on emotional responses, however there is a lack of in-depth examinations of environmental contexts. Hence, the context has become the focus of the next study (see Chapter 6).

Chapter 6: Effect of environmental contexts pertaining to different sound sources on the mood states

6.1 Introduction

The previous chapter investigated how sound types affect emotional outcomes in a controlled environment. In contrast to real urban settings, sound types presented in a controlled environment appears to elicit emotional outcomes differently. For example, traffic sound that had no significant effect in real urban environment had a significant impact on multiple emotional categories while replayed in laboratory. It was concluded that non-acoustic context had a significant effect on the subjective perception of different sound types. Following this conclusion, the chapter then investigated environmental contexts other than urban public settings, and any effects on the subjective evaluation of the various sound types were observed and analysed. The statistical results of this study together with the interpretation through appraisal theory showed evidence that different environment contexts indeed affect the subjective perception of sound types.

The objective of this chapter was to address the following sub research questions:

- If and how do contexts affect mood/emotional states when listening to sounds in general?
- How does context affect mood/emotional states when listening to different types of sound?
- How do audio and visual stimuli in contexts affect emotional responses when perceiving an acoustic environment?
- How do gender differences affect emotional responses under different contexts?

6.2 Methods

6.2.1 Site selection and environmental contexts

To explore the variation in the mood states under different environmental contexts, three non-urban contexts were recorded and used as variables. These contexts consisted of visual cues (static images) and audio recordings. The criteria for the site selection were based on these two components and the remoteness of the sites from the urban setting. Specifically, the audio, visual, and functional characteristics of the selected spaces were expected to have environmental features that significantly differed from the urban public setting. This difference in environmental contexts provides a significant contrast to the urban sounds they were combined into, to allow the effect of environmental context to be easily observed. In particular, space was required to have no or limited visuals of the urban layout or building typology and no or limited visual and audio such as those of traffic and machinery; moreover, conventional circulation or gathering spaces were not considered. The environment types of the three contexts were selected based on these criteria corresponding to an indoor region and courtyard of a Buddhist temple and an alpine meadow from a rural setting. All the contexts were recorded during Summer 2019, under sufficient daylight conditions. The details of these contexts are as follows:

1) The Da Zhao Temple is located southwest of Hohhot city in China. A square with greenery surrounds the north, east, and south sides of the temple. A 2-lane main road and commercial structures are present on the west side of the temple. Beyond the square, a 4-lane main road is present in the east, along with commercial structures in the north and south sides. Despite the urban environment, the temple still feels disjointed from the city, owing to the wall enclosures and greenery surrounding the temple, as shown in Figure 6.1 A ticket is required to enter the temple which serves as an attraction site, which is a common occurrence

pertaining to religious spaces in China. Consequently, the temple is not commonly used as a gathering space. The temple itself is a building complex consisting of several temple halls connected through courtyards. In this study, the main courtyard was considered. This courtyard consists of stone flooring surrounded by temple halls. The temple halls have a brick and wood structure with red-coloured walls and orange-coloured roof tiles and are considerably different structurally from the urban building typology. Figure 6.2 shows that certain statues and a large incense burner are present in the middle of the courtyard, indicating the special functionality (religious purposes) of the space. The temple has an extremely low footfall, usually consisting of a few monks and tourists. There is no line of sight for either vehicles or the city. The audio of the courtyard consists of birdsong (dominant), human voices, and faint and distant traffic sounds.

Figure 6.1 Satellite view of the Da Zhao Temple

2) The main temple hall of the Da Zhao Temple was selected as the indoor space. The hall is dimly lit through the presence of skylights. The central area is surrounded by prayer wheels and is usually where the monks sit, recite chants, and study (Figure 6.2). The audio of the hall consists mainly of the chanting of monks and the sounds of the prayer wheels.

3) The alpine meadow is a rural area located to the north of Huhhot city. The meadow is far from the city and a part of the Yin mountain range. Other than the wooden footpath, as shown in Figure 6.2, there is no visible artificial structure. The audio mainly consists of the sounds of insects and the wind.

In addition, an image of the square of the Sheffield war memorial (Figure 6.2) was also used as the visual stimuli for the three controlled sound clip groups (traffic sound, fountain sound, and street music).

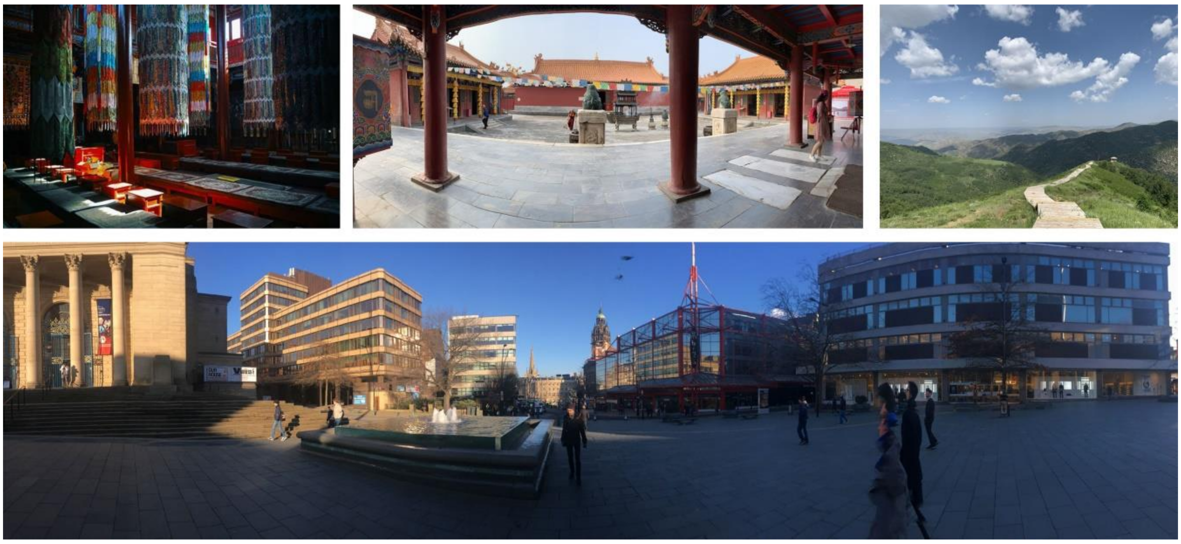

Figure 6.2. Top left: Main temple hall interior; top middle: Courtyard of the Da Zhao temple; top right: alpine meadow view; bottom: Panoramic view of the square of the Sheffield war memorial

6.2.2 Audio stimuli

Twelve audio clips were used as the audio stimuli, which were a combination of the three sound types (street music, traffic sound, and fountain sound) and the environmental context sounds (Da Zhao temple courtyard, monks chanting, and alpine meadow). The three single sound types were recorded in Sheffield city centre, UK, and the three environmental context sounds were recorded in the city of Hohhot and its suburban area, China. All the recordings were performed using a binaural recorder, and the duration of each clip was approximately 10 minutes. During the experimental session, a single audio clip was played and looped at 65 dBA.

The description of the 12 audio clips, along with the assigned notation, is as follows: 1) street music (M); 2) street music–temple courtyard (MTc); 3) street music–monk chanting; (MC); 4) street music–alpine meadow (MA); 5) traffic sound (T); 6) traffic sound–temple courtyard (TTc); 7) traffic sound–monk chanting (TC); 8) traffic sound–alpine meadow (TA); 9) fountain sound (F); 10) fountain sound–temple courtyard (FTc); 11) fountain sound–monk chanting (FC); 12) and fountain sound–alpine meadow (FA) (see also Table 6.1).

6.2.3 Implicit process of mood and emotion

The mood and emotion development process, as summarised by Robinson (2005), consists of the initial triggering by the affective appraisal of a situation, followed by a physiological change in the body systems. Subsequently, cycles of cognitive appraisal and re-appraisal of the situation occur, in a subconscious and rapid manner (Robinson, 2005a). Without conscious labelling, the process can result in a long-lasting mood state, which can affect an individual's subjective evaluation of an environment. Soundscape research, at its foundation, is a study of the interaction between people and the sound environment. The results of most of the laboratory studies rely on the participants' conscious evaluation of the stimuli, as in the case of commonly used methodologies such as audio replays and sound walks. However, the soundscape may affect people implicitly on a psychophysiological level. Brown et al. (2011) termed this phenomenon as the 'experimenter effect'. Specifically, the participants' conscious attention to the soundscape does not necessarily affect the outcome (direct outcomes), and the results (enabled outcomes) may be a result of the interaction of the soundscape with other environmental aspects. In terms of the mood states, psychophysiological or mood changes likely occur owing to a non-conscious reaction towards the environment or stimuli, and such changes later affect the perception of the soundscape through a subjective interpretation.

The current study was designed to account for the subconscious nature of the mood states. The implicit process was realised by limiting the information provided to the participants before and during the experimental session. The participants were told that the experiment was simply a built-environment-related study, and that they would be asked to spend some relaxed time in a meeting room without any other specific or dangerous activities. Later, the participants answered a questionnaire with open questions which were designed to extract information regarding whether conscious evaluations were being made towards the stimuli. Subsequently, the effectiveness of the method was examined through a data analysis in which the differences in the attention toward different sound stimuli was compared. This method facilitated the generation of the most natural reaction of the participants toward the stimuli and thus alleviated the experimenter effect.

6.2.4 Questionnaire

Mood states, in comparison to emotions, are less intense, long-lasting (Keltner et al., 2013; Smith-Lovin et al., 1995) and lack an object. It is only when a person tries to interpret the mood state and attach it to an object (context) does this state become an emotion (Russell, 2003). A similar concept was also later described by Robinson (2005) as the development process of a mood or emotion. Specifically, this process consists of the triggering, monitoring, and labelling stages. Nevertheless, the mood may often be undefined at the monitoring stage, and thus may not be able to be recorded or analysed. The use of a questionnaire can provide cues pertaining to the attention, and help participants to evaluate and define (label) their mood states.

A long form of the POMS questionnaire (McNair et al., 1992) was used here as a tool to measure the mood state. This questionnaire is commonly used in medical studies to monitor patients' mood states and has been proved effective for a variety of demographic groups (O'Halloran et al., 2004; Shin & Colling, 2000; Terry et al., 2003). The questionnaire used here consisted of 65 items, 55 of which corresponded to one of the six mood categories: anger (9 items); confusion (7 items); depression (15 items); fatigue (7 items); tension (9 items): and vigour (8 items). The remaining 10 items corresponded to emotion-related terms that did not correspond to specific moods and were designed to examine the attention. The original questionnaire employed a 5-point Likert scale (1: not at all, 5: extremely). However, in this study, a 6-point Likert scale was used to prevent participants from selecting the middle scale (Van Heerden & Hoogstraten, 1979). In addition, the following four open questions were added at the end of the questionnaire to examine participants' attention and activity during the experiment:

1) During the experiment session, did anything specific attract your attention?
2) If so, how long did you focus your attention on it?
3) During the experiment session, was there anything specific on your mind? If so, please summarise it in a few words (e.g. work-related);
4) Please describe your activities during the relaxation period.

See appendixes C1 and C2 for examples of the questionnaire.

6.2.5 Participants

Power calculations were performed to determine the sufficient number of participants. The A-prior power calculation for MANOVA indicated that to achieve a power of 95% for a small effect size [f = 0.10] with three variables (sound clips, attention to the sound, and gender difference) and six groups (six mood categories), 102 participants were required. In another A-prior power calculation for the ANOVA, it was noted that 288 participants would be required to achieve a power of 80% for the medium effect size [f = 0.25] with 12 groups (12 sound clips). In other words, 24 participants were required per sound clip group. It was impractical to achieve a small effect size for the ANOVA, which would require 1,692 participants. However, a small effect was unlikely to be neglected due to the ability of the MANOVA to detect any small effect and avoid type II errors. Moreover, the results of the MANOVA were considered when interpreting the results of the ANOVA. To compensate for any missing or invalid data, 300 participants were recruited instead of 288.

Ethics approval (160237180) was provided by the University of Sheffield. All the participants were recruited from the Inner Mongolia University of Technology. The recruitment information was announced during lectures. Participants were required to have normal perceptibility (i.e. normal hearing and sight). Any mild disability that the participants were unaware of did not impact the experiment outcome, as the person could still evaluate their surroundings sufficiently. A total of 300 undergraduate students were recruited: 133 male, 179 female, and 8 unspecified. The ages of the participants ranged from 17 to 25. To secure a large sample size, the undergraduate student (teenagers) demographic was considered as the population of interest; therefore, the demographic difference must be taken into account when generalising the results.

6.2.6 Experiment design

The experiment was performed in a meeting room in the architecture department of the Inner Mongolia University of Technology, China. The meeting room can fit approximately 15 individuals without crowding. For the 300 participants (participants were newly recruited, and the same participant's size calculations from chapter 5 also applied in this study), a total of 24 sessions were conducted for 12 different stimuli (audio clip) groups (12 to 13 participants per session). To simulate the outdoor sound propagation condition, sound-absorbing foam was placed at the corners and edges of the room walls to achieve a reverberation time of 0.3 s to 0.5 s for a frequency of 500 Hz to 1,000 Hz. Tables and chairs were provided for the participants, and tea and coffee were served (see also Figure 5.1).

A pair of speakers and a laptop were set up at one end of the room for the audio replay. Only one audio clip was played and looped during each session. To reduce the potential bias caused by the difference in the sound levels, all audio replays were played at 65 dBA, and the sound level was measured using a 01 dB sound level metre prior to each session. A single static photo was projected onto the screen in the meeting room to provide a visual cue for each audio clip. A total of four pictures were used, three of which were captured onsite. The remaining picture was downloaded from the internet, as the temple forbade indoor photography. The combinations of the images (Figure 6.2) and audio clips were as follows:

1) photo of the square of the Sheffield war memorial, as a visual cue for sound clips M, T and F; 2) photo of the Da Zhao temple courtyard, as a visual cue for sound clips MTc, TTc and FTc; 3) photo of the Da Zhao temple interior, as a visual cue for sound clips MC, TC and FC; 4) photo of the alpine meadows, as a visual cue for sound clips MA, TA and FA. (See Table 6.1).

Table 6.1 audio content of the audio clips

Clips	Context	Audio
1	Urban (Sheffield City Centre)	Street music (M), Traffic sound (T), Fountain sound (F)
2	Temple courtyard	Street music with Temple courtyard (MTc), Traffic sound with Temple courtyard (TTc), Fountain sound with Temple courtyard (FTc)
3	Temple interior (Monk Chanting)	Street music with Temple interior (MC), Traffic sound with Temple interior (TC), Fountain sound with Temple interior (FC)
4	Alpine meadow	Street music with alpine meadow (MA), Traffic sound with alpine meadow (TA), Fountain sound with alpine meadow (FA)

Before the start of each experiment session, the audio clip was played and its related picture was projected on to the screen before the participants arrived. As the participants arrived, they were asked to sit around the table and relax for 30 minutes; tea and coffee were served. There were no strict rules on the specific activities that the participants could perform during this period, so long as the activity did not significantly reduce the visual and audio perception of the participants (such as wearing headphones). The purpose of this period was to allow the participants to simulate a relaxation period in a public space and sufficiently absorb the designed stimuli. After 30 minutes, each of the participants were asked to fill in a POMS questionnaire, to observe their mood states and the activity performed during the experiments. Also refer to Figure 5.2 for the experimental procedure.

6.2.7 Data analysis

The data were analysed by MANOVA, discriminant function analysis, and subsequent univariate. The initial MANOVA was conducted to identify if a difference in the mood state occurred among the independent variables, namely, the difference in the audio clips (contexts and sound types), gender, and influence of noticing the stimuli. Subsequently, the discriminant function analysis was conducted to group the dependent (mood states) and independent (sound types and contexts) variables to clarify the trends among the groups. However, this discrimination cannot identify the relationship between the single factors and mood states. The relationship was examined using univariate test and the post-hoc analysis in which one-to-one comparisons were made between each sound type and their context combinations. Figure 6.3 shows the complete data analysis process.

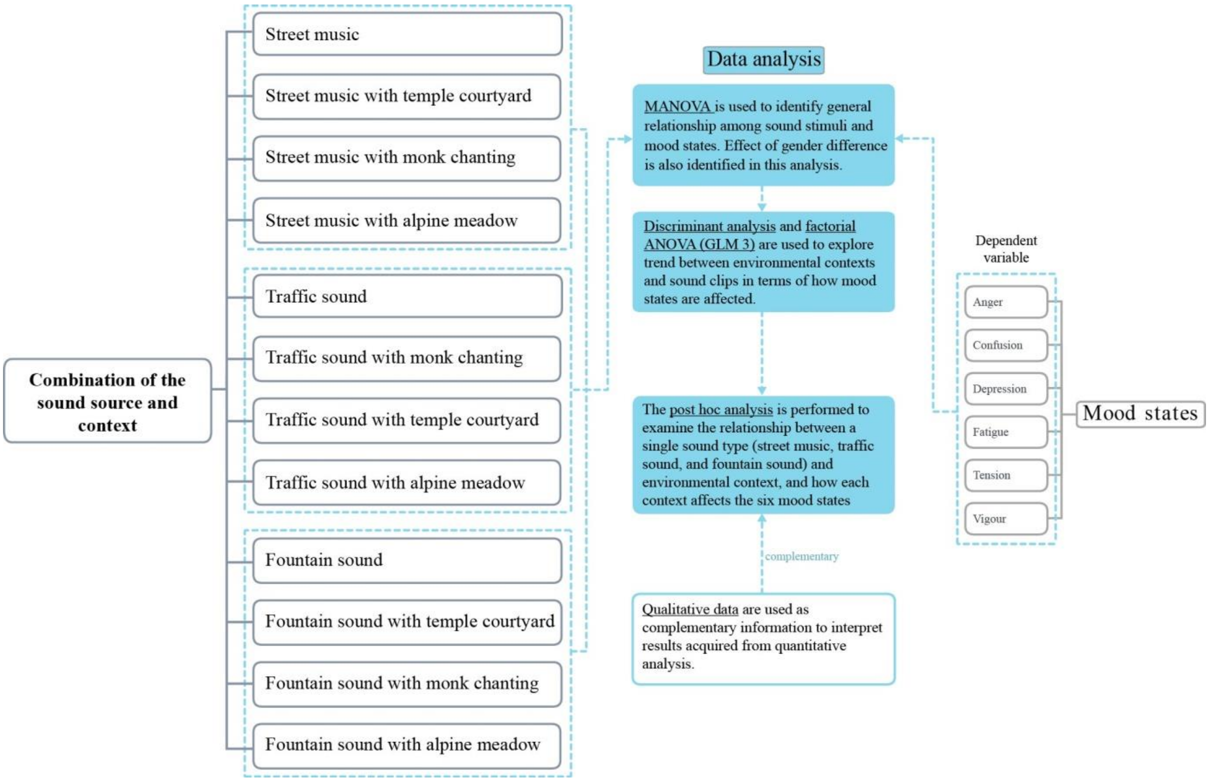

Figure 6.3 Data analysis process

The assumptions for MANOVA (the assumptions of multivariate normality and homogeneity of covariance matrices) were checked. The assumption of multivariate normality was checked through histograms (see Figure 6.4). The figure shows that anger, depression, fatigue, confusion and tension scores were skewed towards the left, indicating the data were not normally distributed, in turn, violating multivariate normality.

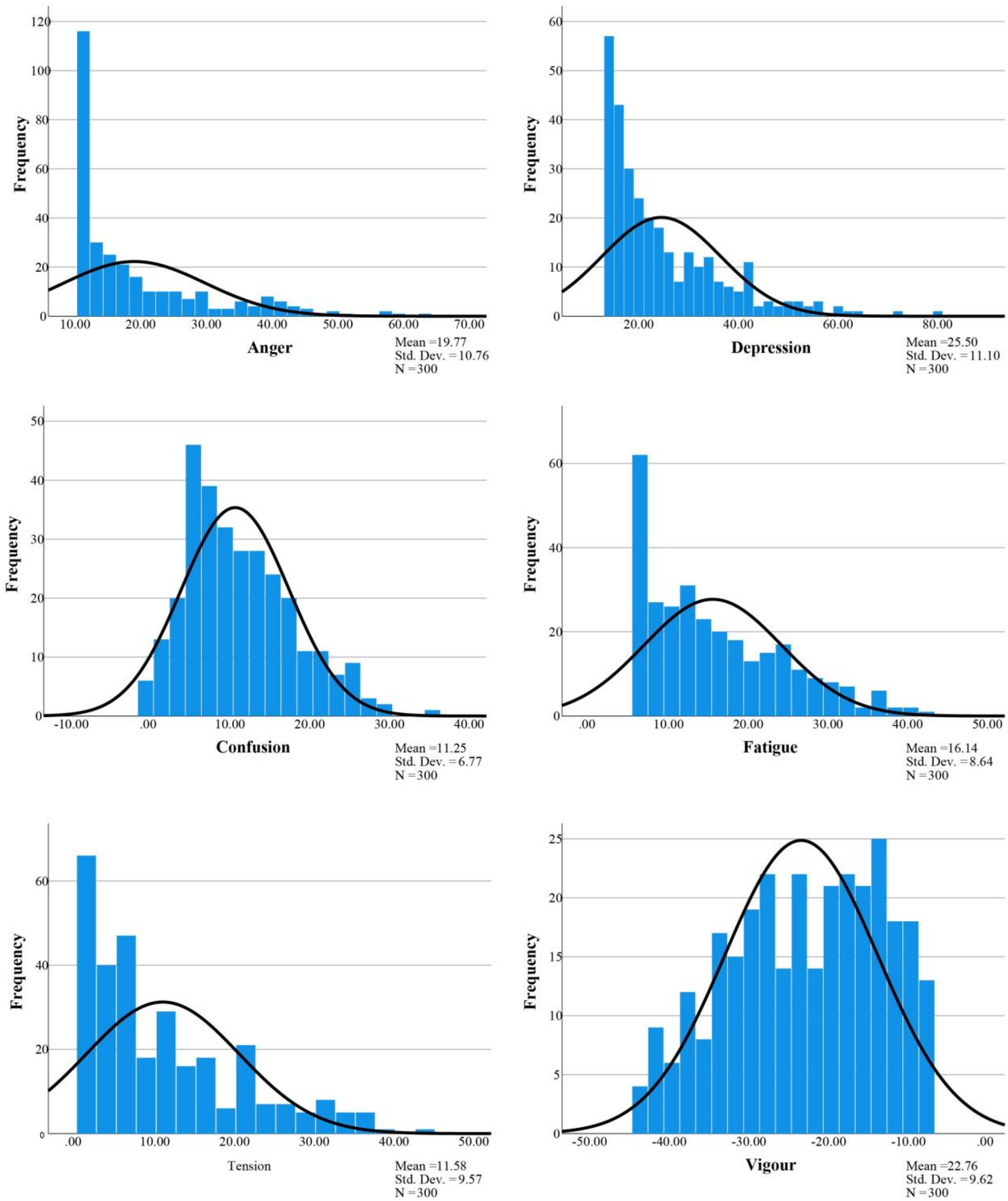

Figure 6.4 Frequency against total mood score rating histograms of six mood states

A Levene's test was performed to examine the assumption of homogeneity of covariance matrices (Box's test was also supposed to be conducted, however, as the group sizes were equal Box's test is unreliable and should be disregarded), the result is shown in Table 6.2.

The table shows that all mood states potentially violate the assumption of homogeneity of covariance matrices (indicated by significant values p < .05).

		Levene Statistic	df1	df2	Sig.
Anger	Based on Mean	2.91	45	246	0.00
	Based on Median	1.14	45	246	0.27
Confusion	Based on Mean	1.57	45	246	0.02
	Based on Median	0.98	45	246	0.51
Depression	Based on Mean	1.87	45	246	0.00
	Based on Median	0.91	45	246	0.64
Fatigue	Based on Mean	1.90	45	246	0.00
	Based on Median	1.10	45	246	0.32
Tension	Based on Mean	2.80	45	246	0.00
	Based on Median	1.35	45	246	0.08
Vigour	Based on Mean	1.85	45	246	0.00
	Based on Median	1.15	45	246	0.25

Table 6.2 Levene's test of equality of error variances tests the null hypothesis that the error variance of the dependent variable is equal across all groups

However, when group sizes are equal MANOVA is robust against the violation of normality. Similarly, when group sizes are equal Pillai's trace test (of MANOVA) can also be robust against the violation of homogeneity of covariance matrices Hence, Pillai's trace test was chosen for the MANOVA.

6.3 Results

6.3.1 Overall difference and trends in the contexts and mood states

To identify if any effect existed among the contexts, a MANOVA (Pillai's trace) was performed. The results indicated that differences existed in the mood scores for different sound clip groups [V = 0.43, F(66, 1476) = 1.74, p < .001]. This result indicated that the differences among the sound types and their combination with the contexts significantly affected the mood states. The subsequent univariate test confirmed that all six moods were affected by the differences in the sound clips: anger [F(11, 246) = 3.08, $p \leq .001$, $\omega^2 = .036$], confusion [F(11, 246) = 2.96, $p \leq .001$, $\omega^2 = .035$], depression [F(11, 246) = 1.93, $p < .05$, $\omega^2 = .016$], fatigue [F(11, 246) = 3.27, $p < .001$, $\omega^2 = .039$], tension [F(11, 246) = 3.57, $p < .001$, $\omega^2 = .045$], and vigour [F(11, 246) = 2.36, $p < .01$, $\omega^2 = .024$][1]. Additionally, the participants' noticing the sound [N = 134] and the associated interaction with the difference in the sound clips did not significantly affect the mood states [$p > .05$]. This result indicated that without the verbal context of the experiment and the sound sources, the participants' attention towards the sound stimuli did not affect their mood states, thereby demonstrating that implementation of the implicit process was successful (see also Table 6.3).

Table 6.3 Multivariate test between sound clips, notice of sound stimuli and gender difference

Effect	Value	F	Hypothesis df	Error df	Sig.
Sound clip difference	0.433	1.741	66.000	1476.000	0.000
notice sound stimuli	0.037	1.539	6.000	241.000	0.166
Gender difference	0.043	1.799	6.000	241.000	0.100
Sound clip difference with Notice of sound stimuli	0.296	1.162	66.000	1476.000	0.180
Sound clip difference with Gender difference	0.318	1.378	60.000	1476.000	0.031
Sound clip difference with Notice of sound stimuli and Gender difference	0.166	0.701	60.000	1476.000	0.960
Notice of sound stimuli with Gender difference	0.031	1.275	6.000	241.000	0.269

Significant, $p \leq .05$

To examine the influence of the different environmental contexts on the mood states, a discriminant function analysis was conducted to group the sound clips and mood states. The results identified six functions, and the 1st and 2nd functions explained most of the variance. Specifically, the 1st function explained most of the variance [49.1%, *canonical* $R^2 = .22$],

[1] ω^2 Effect size

followed by the 2nd function, which explained 25.7% of the variance [*canonical* R^2 = .13]. Together, the six discriminant functions could significantly differentiate the sound types and their combinations with the environmental contexts [Λ = 0.60, X^2 (66) = 149.17, p < .001]. Even when the 1st function was removed, the remaining group could reasonably differentiate the sound clips [Λ = 0.76, X^2 (50) = 78.93, p < .01]. However, if the 2nd function was removed as well, the sound clips could not be differentiated by the remaining functions [Λ = 087, X^2 (36) = 39.98, p > .05]. The correlation between the sound clips and mood indicated that anger [r = .84], confusion [r = .74], depression [r = .61], fatigue [r = .71], and tension [r = .85] loaded highly on the 1st discriminant function, whereas vigour loaded highly on the 4th function [r = .73]. These results indicate that anger, confusion, depression, fatigue and tension shared a similarity in emotional responses whereas vigour shared significantly less similarity with the rest of the emotional categories.

Figure 6.5, which shows the discriminant function plot, along with Table 6.4, indicates that the 1st function differentiates the sound clips T, F, FTc and FA from the remaining clips. The 2nd function differentiates M, F, MA, and MC, from the remaining clips. F and its context combinations (FTc, FA, and FC) can be differentiated consistently by the first two functions, T and its context combinations (TTc, TA and TC) can be differentiated only by the first function, and M cannot be clearly differentiated by either of the two functions. The results of the function discriminant analysis suggest that the context differences considerably influence the six moods. This difference was particularly notable for T and its context combinations and for F and its context combinations. Nevertheless, the difference did not occur for M and its context combinations.

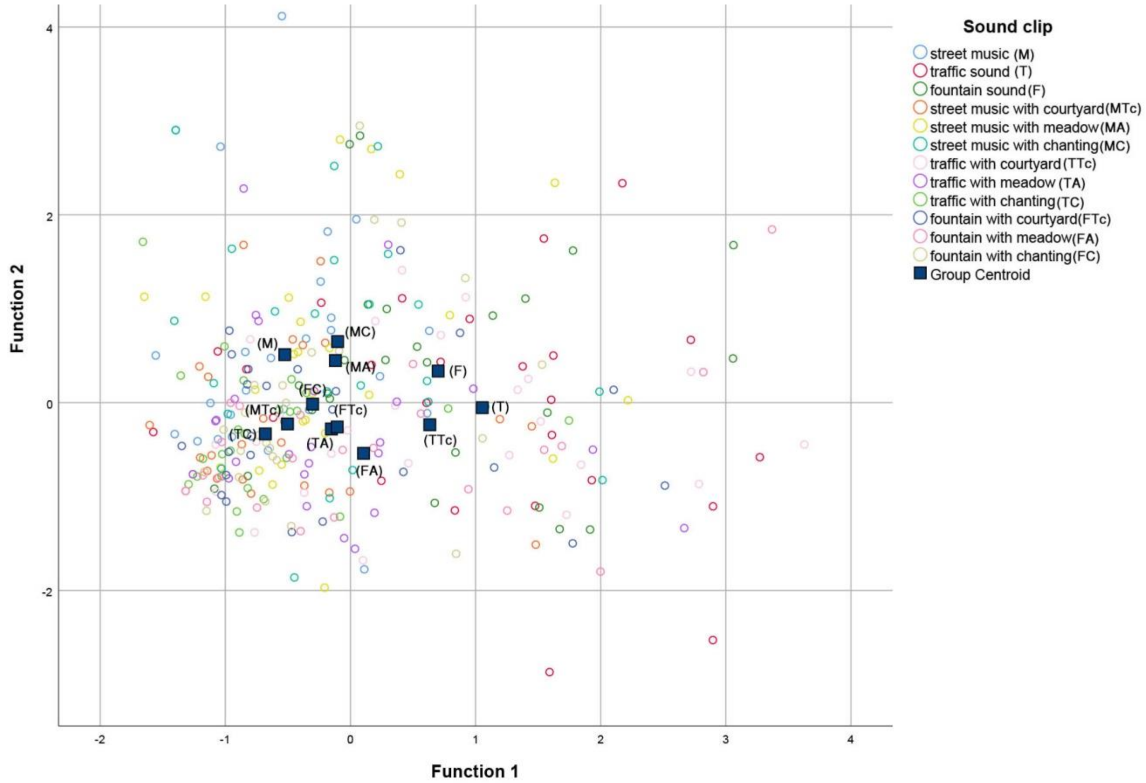

Figure 6.5 Canonical discriminant functions: Distribution of the 12 sound clips in relation to the first two discriminant functions (major).

Table 6.4. Unstandardised canonical discriminant functions evaluated at the group means (12 audio clips)

		M	T	F	MTc	MC	MA	TTc	TC	TA	FTc	FC	FA
Discriminant Function	1st	-0.525	1.054	0.701	-0.503	-0.103	-0.120	0.634	-0.680	-0.152	-0.106	-0.303	0.105
	2nd	0.511	-0.054	0.336	-0.227	0.650	0.448	-0.236	-0.333	-0.280	-0.259	-0.016	-0.540

M: Street music
MTc: Street music with temple courtyard
MC: Street music with monk chanting
MA: Street music with alpine meadow

F: Fountain sound
FTc: Fountain sound with temple courtyard
FC: Fountain sound with monk chanting
FA: Fountain sound with alpine meadow

T: Traffic sound
TTc: Traffic sound with temple courtyard
TC: Traffic sound with monk chanting
TA: Traffic sound with alpine meadow

6.3.2 Effect of contexts on the different sound type groups

To examine the individual context and its effect on the mood states, a post hoc analysis was conducted after the univariate test (factorial ANOVA). Although the analysis considered every possible two-and-two comparisons of the mood states among the sound clip groups, the focus in this study was to compare each single sound type (T, F, M) and their combinations with the contexts. The post hoc analysis result indicated that the different contexts significantly influenced the different mood states depending on the sound type:

a) T: When combined with the temple courtyard context, traffic sound did not exhibit a significant effect on any of the moods [$p > .05$], meaning that neither the birdsong nor the visual stimulus of the courtyard made a significant difference in how the traffic sound influenced the mood states. The monk chanting context exhibited a significant effect on most of the moods [$p < .05$] except vigour [$p > .05$]. The alpine meadow context exhibited a significant effect only on anger [$p < .05$] and fatigue [$p < .05$]. The mean mood score reduced when the contexts were added.

b) F: The temple courtyard context exhibited a significant effect on confusion and fatigue [$p < .05$]. The monk chanting context exhibited a significant effect on anger and depression [$p < .05$]. The alpine meadow context significantly affected only confusion [$p < .05$]. Similar to the case of the traffic sound, the mean mood score was lowered when the contexts were added to the fountain sound.

c) M: The street music did not exhibit any difference between itself and its context combinations [$p > .05$]. The results indicated that the contexts did not have a significant effect on how the street music influenced the mood states. Usually, street music is aimed to attract the attention of passengers, meaning that in most cases street music is consciously assessed by people in the context of urban public spaces. Consequently, the music used in this study was a dominant sound. This dominant nature of street music likely overshadowed any effect that the contexts may have had. Furthermore, relaxing music is known to lower the arousal level in the presence of stress (Thoma et al., 2013), and the music used in this study had a slow tempo, which likely had a calming effect. This effect was observed in the Bonferroni post hoc comparison of the tension score corresponding to M [0.28±6.81 minutes] and T [12.48±10.06 minutes, $p < .001$] or F [10.16±11.23 minutes, $p < .05$]. In both cases, the tension score decreased when street music was used as the audio stimuli. The positive effect of the context in terms of the reduction in the negative moods scores was observed in the other post-hoc comparisons (i.e. traffic and fountain sound groups), demonstrating that the contexts affected the mood states, even for different sound sources. However, the positive effect of the contexts did not significantly improve the music's ability to reduce stress, as indicated in Table 6.5.

Table 6.5 Post hoc analysis among sound clips for the mean score of the mood states

		M v MTc	M v MC	M v MA	T v TTc	T v TC	T v TA	F v FTc	F v FC	F v FA
Games -Howell	Anger	-1.360	-4.200	-2.360	4.320	14.000***	11.760**	8.280	11.120*	6.680
Games -Howell	Fatigue	4.520	-2.440	-1.640	3.840	11.320***	8.400*	8.280*	7.120	7.400
Games -Howell	Tension	-0.280	-3.760	-1.940	2.600	11.920***	8.600	5.600	8.280	5.680
Bonferroni	Confusion	0.120	-1.360	-2.880	1.600	8.360***	5.160	7.000**	5.720	6.440*
Bonferroni	Depression	0.600	-4.320	-0.960	3.480	11.200*	9.920	9.600	11.800*	10.960
Bonferroni	Vigour	2.960	-4.160	-2.280	0.360	8.360	3.320	1.640	4.080	5.880

M: Street music
MTc: Street music with temple courtyard
MC: Street music with monk chanting
MA: Street music with alpine meadow

T: Traffic sound
TTc: Traffic sound with temple courtyard
TC: Traffic sound with monk chanting
TA: Traffic sound with alpine meadow

F: Fountain sound
FTc: Fountain sound with temple courtyard
FC: Fountain sound with monk chanting
FA: Fountain sound with alpine meadow

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

6.3.3 Effect of visual and audio stimuli in the contexts

Visually, the Temple Courtyard (Tc) was distinct from the urban contexts. The layout was characteristic of a traditional Chinese courtyard (Figure 6.1), meaning that the space was self-contained and isolated both visually and acoustically. It has been reported that an enclosed space in a religious setting (similar to the temple context used in this study) can enhance the tranquillity in a soundscape (Jeon, Hwang & Hong, 2014). In terms of the PCM, tranquillity is located in the uneventful and pleasant category, opposite to the tension mood. However, in this study, the tension score did not exhibit any significant difference when the temple courtyard context was combined with any of the three sound types. This result suggests that the tranquillity provided by the enclosed religious space was limited and depended on the sound types presented in a sound environment. Acoustically, the birdsong of the courtyard context did not affect the mood scores when combined with traffic. This result was expected as the audio playback occurred at 65 dBA, in which the traffic sound was relatively loud. In Hao et al.'s study (Hao et al., 2016), the masking effect of the birdsong in terms of the pleasantness was significant only when the traffic sound level was low (< 52.5 dBA). The only sound that was affected by the temple courtyard context was the fountain sound, where the fatigue and confusion mood scores were significantly different in the fountain sound and temple courtyard context combination compared to the fountain sound on its own. However, this effect on fatigue and confusion mood categories did not indicate the context's effect on pleasantness but rather the initial increased confusion of the fountain sound was easier to understand (indicated by decreases of confusion score) with the context of the Tc (see Table 6.5, indicated by the positive value of the mean difference).

In contrast, the effect of the monk chanting (C) context on the mood state was more notable. Visually, the context exists in an indoor environment. The room is dimly illuminated by the surrounding skylights. The colour scheme primarily consists of crimson-coloured furniture and interior walls and columns with multi-coloured religious flags hanging from the roof (Figure 6.2). The overall space exhibits a sacred setting in contrast to the relaxing courtyard. There is a clear shift of functionality from the temple courtyard to the indoor region. This sacredness is likely to be perceived as positive in terms of emotional experiences, as shown in the comparison between groups T and TC. All the negative mood scores were significantly affected. The audio aspects of the context consisted of monks chanting, the occasional sound of the rotating prayer wheels, and the quiet conversations of tourists. The acoustic elements were focused on human sounds in contrast to the natural sounds of the courtyard. In a previous case study by Jeon et al. (2014), religious chanting in Buddhist temples was hypothesised to elicit pleasantness in visitors. This finding was in agreement with that of the present study. In the comparison between the F and FC groups, a significant difference was noted only for depression and anger. Along with the results of the T and TC groups, it can be suggested that the effect of the monk chanting context was limited when combined with sounds that already elicited a positive evaluation, such as water sounds (Yang & Kang, 2005a, 2005b). Furthermore, human sounds have been reported to have a significant influence on the perceived eventfulness (Viollon, Stéphanie & Lavandier, 2000). However, the eventfulness was expected to only have a limited effect on the moods in this study, as most mood categories can only be differentiated in terms of pleasantness and unpleasantness (other than confusion) and not in terms of eventfulness (i.e. confusion, depression and vigour; for further discussion, see Section 3.4).

The alpine meadow context consisted of a natural visual and audio setting. The natural context exhibited a limited effect on anger and fatigue when combined with T, and a limited effect on confusion when combined with F. The results suggest that the natural context reduced the negative emotions perceived in the traffic and fountain sound. The results agreed with those of previous studies, in which visuals of greenery were reported to improve the environmental preference (Hong & Jeon, 2013), and the audio of natural sounds such as birdsong and water sounds likely improved the perceived pleasantness of the sound environment (Hao et al., 2016; Jeon et al., 2010). However, the effect of the natural context on the perceived pleasantness cannot be widely applied. Specifically, in a study on how the interaction with urban greenery could affect anxiety of elderly people, it was found that 'awareness of the natural experience' was a determining factor of the outcomes (Dzhambov & Dimitrova, 2014). Furthermore, it has been reported that although the visual stimuli of greenery can induce perceived tranquillity, the effect is small in terms of the anxiety, even though the two moods are on the opposite sides of the same axis in the PCM (uneventful–pleasant and eventful–unpleasant for tranquillity and anxiety, respectively) (Watts et al., 2016). These findings indicated that more dimensions in the soundscape study of mood states exists than simply pleasantness and eventfulness, and this assumption suits the idea of appraisal theory where each emotion is composed of a number of appraisal components. The PCM also suggests the familiarity of sound as the third dimension for soundscape evaluation; however, the extent of the influence of the familiarity on the mood states is unclear. The results of this study indicate that the pleasantness induced by the natural environment featured only in a few mood states, and more dimensions likely contribute toward the differentiation of the sound sources.

6.3.4 Gender differences

A mood difference was observed in the interaction of the sound clips and genders [$V = 0.32$, $F(60, 1476) = 1.38$, $p < .05$], although this effect only occurred in the case of depression [$F(10, 253) = 1.94$, $p < .05$, $\omega^2 = .017$] and fatigue [$F(10, 246) = 2.82$, $p < .01$, $\omega^2 = .031$]. On its own, gender difference did not significantly affect the mood scores [$p > .05$]. Specifically, the gender difference exhibited a significant small to medium effect on the mood states. Several studies have reported findings that are in agreement with this assumption. In a study of urban squares, Yang and Kang (2005b) noted that females appeared to be more aroused by mood-related sounds. In a comparison study between urban and rural areas, Pheasantet al. (2008) observed that the male rating of tranquillity was higher than that of females in two natural (rural) environments. Another study supported this trend from a physiological basis, in which the heart rate was noted to reduce when people were presented with pleasant sound compared to that in the case of unpleasant sounds, and this trend was more significant in males than in females (Hume & Ahtamad, 2013). All these studies reported that the degree of perceived pleasantness of sounds was different for different genders; however, there exists a disagreement in terms of which gender was affected (aroused) the most. It is hypothesised here that this difference is because of the contexts and sound sources' differences included in the various studies.

6.3.5 Analysis of underlying components

A Principal component analysis (PCA) was conducted to examine whether the underlying components of the current data sets were in agreement with the 6 mood states proposed by POMS. In turn, the validity of POMS was examined. 65 items were examined through PCA with oblique rotation (promax, kappa = 4). The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) = .95 indicating the data were adequate for PCA (Kaiser (1974), recommends a bare minimum KMO value of 0.5 for the sample to be adequate). Bartlett's test of sphericity X2 (2080) = 16062.88, $p < .001$ indicating correlation between items was sufficient for PCA. 10 components were identified with the criterion of eigenvalues of over 1 (the Kaiser's criterion). The 10 components in combination explain 68.33% of the total variances (see Table 6.6).

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	24.76	38.09	38.09	24.76	38.09	38.09	20.60
2	7.49	11.52	49.61	7.49	11.52	49.61	9.53
3	2.77	4.25	53.87	2.77	4.25	53.87	12.79
4	1.86	2.85	56.72	1.86	2.85	56.72	7.89
5	1.56	2.40	59.12	1.56	2.40	59.12	16.73
6	1.32	2.03	61.15	1.32	2.03	61.15	11.25
7	1.25	1.92	63.07	1.25	1.92	63.07	11.74
8	1.21	1.85	64.93	1.21	1.85	64.93	8.34
9	1.14	1.76	66.69	1.14	1.76	66.69	7.73
10	1.07	1.64	68.33	1.07	1.64	68.33	6.96

Table 6.6 Total variance explained Initial analysis based on eigenvalues, only showing components with eigenvalues above 1 (Kaiser's criterion)

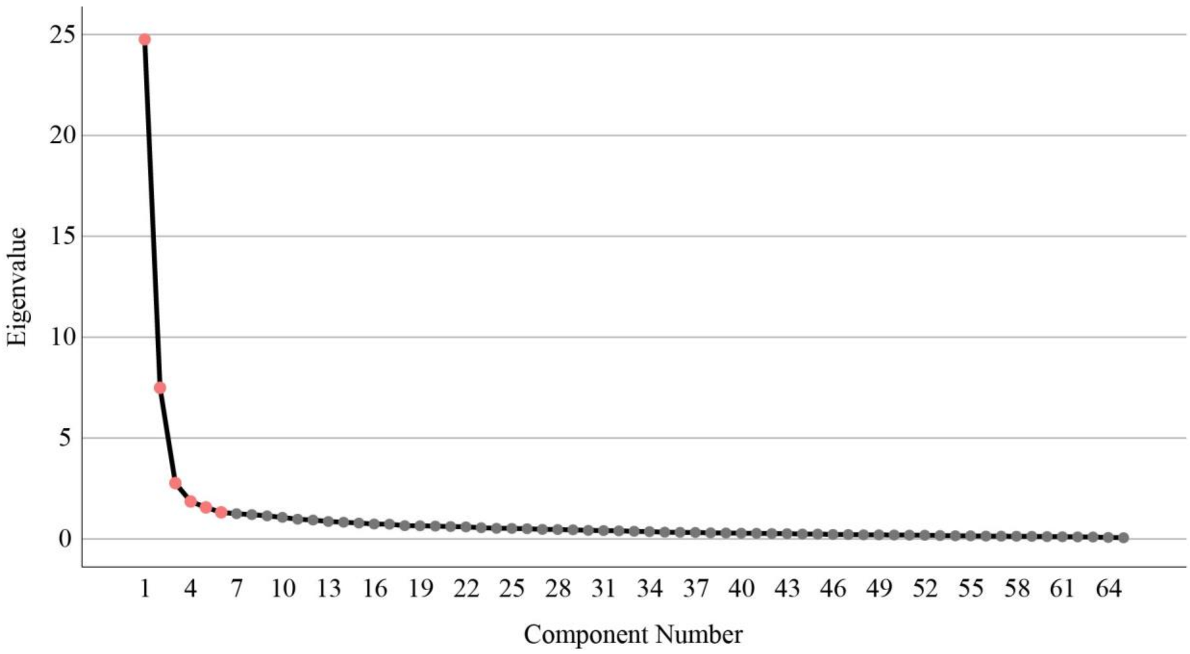

Figure 6.6 Scree plot of eigenvalue against components

The scree plot (Figure 6.6) shows the point of inflexion is at the 6th component. From both the eigenvalue and the scree plot, keeping both 6 and 10 components is justified. Although keeping 6 components is more consistent with the 6 mood states proposed by POMS, all 10 components were examined.

	Component									
Items	1	2	3	4	5	6	7	8	9	10
Angry	0.95									
Furious	0.91									
Peeved	0.91									
Grouchy	0.77									
Ready to fight	0.74									
Unhappy	0.73									
Bad-tempered	0.73									
Resentful	0.59									
Rebellious	0.59									
Deceived	0.49									
Annoyed	0.45				0.44					
Alert	0.45									
Bitter	0.44									
Weary	0.43									

Hopeless*	—									
Restless*	—									
Terrified*	—									
Efficient		0.86								
Trusting		0.82								
Helpful		0.80								
Carefree		0.79								
Full of pep		0.77								
Vigorous		0.70								
Considerate		0.68								
Good-natured		0.68								
Cheerful		0.48								
Fatigued			0.81							
Listless			0.78							
Exhausted			0.74							
Bushed			0.74							
Worn out			0.72							
Sluggish			0.61							
Muddled			0.56							
Sorry for things done				0.73						
Guilty				0.66						
Desperate				0.56						
Worthless				0.44						
Sad*	—									
Miserable					0.72					
Lonely					0.68					
Anxious					0.66					
Nervous					0.64					
Gloomy					0.52					
Helpless					0.48					
Uneasy*	—									
Clear-headed						0.83				
Lively						0.78				
Activity						0.69				
Energetic						0.66				
Friendly						0.53				
Relaxed*	—									
Tense							0.68			
Panicky							0.66			
On edge							0.61			
Shaky*	—									
Forgetful								0.75		
Uncertain about things								0.64		
Unable to concentrate								0.43		

Unworthy									0.74	
Confused									0.73	
Bewildered									0.54	
Sympathetic										0.71
Spiteful										0.61
Discouraged*	—									
Blue*	—									

Table 6.7 Pattern matrix of unique factor loadings after factor rotations in the orders contain the most items to the least items
* unique factor loading below 0.4

Unique factor loadings of each item corresponding to 10 components were shown in Table 6.7. The component containing most items is listed at the top of the table other components are listed in descending order. The underlying mood states (themes) representing each component are as follows: 1) anger (11 anger items, 3 non-anger items), 2) positivity (5 vigour items and 4 friendliness items), 3) fatigue (5 fatigue items and 2 non-fatigue items), 4) depression (4 depression items), 5) depression (5 depression items and 3 non-depression items), 6) vigour (3 vigour items and 2 items related to positivity), 7) tension (3 tension items), 8) confusion (3 confusion items), 9) confusion (2 confusion items and 1 depression items), 10) 2 items that are not related and too ambiguous to label. (See components and underlying theme in Table 6.8)

Components	1	2		3	4	5	6	7	8	9	10
Items (emotional related words)	Angry	Cheerful		Fatigued	Sorry for things done	Sad	Lively	Tense	Forgetful	Confused	
	Furious	Efficient		Exhausted	Guilty	Miserable	Activity	Panicky	Uncertain about things	Bewildered	
	Peeved	Carefree		Bushed	Desperate	Lonely	Energetic	On edge	Unable to concentrate		
	Grouchy	Full of pep		Worn out	Worthless	Gloomy					
	Ready to fight	Vigorous		Sluggish		Helpless					
	Bitter		Trusting								
	Bad tempered		Helpful								
	Resentful		Considerate								
	Rebellious		Good natured								
	Deceived										
	Annoyed*										
Distinctive emotion	Anger	Vigour	Friendliness	Fatigue	Depression	Depression	Vigour	Tension	Confusion	Confusion	—
Numbers of items related to the emotion	11	5	4	5	4	5	3	3	3	2	—
Items did not fit the mood states categories	Unhappy			Listless		Anxious	Clear headed			Unworthy	Sympathetic
	Alert			Muddled		Nervous	Friendly				Spiteful
	Weary					Annoyed*					

* items that shared between two components

Table 6.8 list of items attributed to each component and the underlying mood state that represented each component

As shown in Table 6.8, to cover all 6 mood states proposed by POMS, at least the first 8 components from the PCA need to be considered. Among these 8 components, anger, fatigue, depression, tension and confusion can be relatively clearly separated and themed. Vigour was the only mood state that was attributed to other items that were not related to itself. This appears in component 2, where the vigour item was mixed with items that were considered not emotion specific. These non-emotional items were identified in the first thesis study (Chapter 4) as 'friendliness' (see section 4.3.6) and were also discovered in another study (Gibson, 1997). This mix between the vigour and friendliness items indicated that it was difficult for participants to separate the meaning between the two themes. This mixture between the vigour and friendliness items was not a lone case. In both the first and second studies (chapters 4 and 5), there was a friendlyness item mixed with vigour themed component (see Table 4.23, component 5) and there was also a vigour item mixed with a friendliness themed component (see Table 5.12, component 8). These mixtures in the previous chapters were disregarded due to the small number of items involved (at least on one side of the mixture). But in the current PCA result, the number of items between the two mood states were relatively large and equal (5 vigour items and 4 friendliness items), and hence cannot be disregarded. The only underlying factor that both emotional themes shared was the notion of positivity contained within the two groups of items, and this also appears to be where the confusion was. The different degrees of mixture presented across the three chapters (chapters 4, 5 and 6) indicates that such confusion may be the result of the changes in context, as chapter 6 was focused on the effect of context change and this was also where the mixture between the vigour and friendliness was most significant.

Among the mood states that can be clearly defined by the components from the PCA, two mood states were split between 2 of the 10 components. They were depression (split between components 4 and 5) and confusion (split between components 8 and 9). The divide between mood states indicated there were underlying sub-factors within this state. For confusion, the sub-factor appeared to be whether the items were action-orientated, however, there was no apparent sub-factor explaining why depression items were divided. These mood state divisions in the PCA were less likely to affect the interpretation of the results based on POMS' categorisation, as the components containing these mood states did not mix with items other than their emotional theme. The only component that should be disregarded was component 10 as the items included within shared no clear underlying theme.

Some items did not fit the emotional theme to which they were attributed. These items were most likely the result of participants misunderstanding the items or attention loss during the survey sessions. The misunderstanding of items could be caused by meaning lost in translation or the ambiguous meaning contained in the original POMS questionnaire. However, the number of items being misattributed was small and unlikely to affect the result of the study.

In summary, to interpret results of the study based on the 6 mood states proposed by POMS were valid. The only mood state that should be interpreted with a caveat was 'vigour', where only general positivity of the concept of vigour should be considered.

6.4 Discussion

6.4.1 PCM and mood categories

The PCM is a model used to measure and explain subjective perceptions of acoustic environments, and it is widely used to evaluate the perceived soundscape quality. The model was developed by Axelsson et al. (2010), with reference to Russell's (2003) core affect model as a part of the theoretical foundation of the PCM. The two models include similar components, namely, pleasantness–unpleasantness and eventful–uneventful (or activation–deactivation in the core affect). In the core affect model, the two components are used to explain the perceived moods and emotions from an environment. This ability to evaluate mood states is also applied in the PCM. However, as noted previously in Section 2.1.2, this consideration may not be sufficient for certain specific categories. Russell argued that the traditional approach for the categorisation of moods and emotions was unclear and led to confusion in terms of the boundaries and definitions, and he thus developed the core affect model (Russell, 2003). However, the author specified that the core affect alone was not sufficient to define all the mood states, and that a clear mood categorisation was necessary to study the specific moods. To better assess the perceived sound quality, the PCM recommended the use of a third component, familiarity (Axelsson et al., 2010). However, the relevance of the familiarity component in relation to mood states remains unclear. It must be noted that the two components (pleasantness and activation/eventfulness) in the core affect model can be used to directly assess the mood states; however, in the PCM, the two components are used to assess the mood-related aspect of sound. Although this difference does not affect the current discussion, it must be taken into account.

6.4.2 The effect on mood category interpreted through appraisal theory

To achieve a better understanding of categorised emotions, the results were analysed through the model proposed by appraisal theory. Each of the six moods was analysed individually to assess whether they were emotion per se. If so, what are their core effect (the defining nature of the emotion) and appraisal patterns (specific appraisal components that caused the emotional response)? If not, what is their role in the emotional appraisal process?

A number of factors need to take into consideration when interpreting the results based on appraisal theory. First, the goals of an individual are critical to the appraisal process and how an environmental encounter (factors of the experiment) are appraised based on one goal directly related to the outcome of emotions. Participants' short term goal in the experiment was to try to relax as asked. Any activity performed by the participants was assumed to achieve a state of relaxation, and emotional outcomes depended on whether it was congruence or incongruence to this goal. Second, the emotions in this study can be both produced explicitly through conscious appraisal or implicitly where emotions are triggered automatically based on the memory of a past explicit process (emotional memory) without engaging conscious thinking. (see Sections 3.1 and 3.2 for an explanation of the processes). Out of the 300 participants, 134 reported in their questionnaire that they noticed the sound and context that were being examined, indicating that a similar percentage (44.7%) of participants engaged in an explicit conscious appraisal process towards the studied factors. The rest of the participants were likely to respond to the factors based on their emotional memories. For the abbreviations of the sound stimuli used in the following sections please refer to Table 6.1.

6.4.2.1 Anger

The post-hoc test of factorial ANOVA analysis showed that anger scores significantly differed between (1) T and TC (where T has a higher mean value in anger than TC); (2) T and TA (where T has a higher mean value in anger than TA); and (3) between F and FC (where F has higher mean value in anger than FC). The results of the post-hoc analysis showed that C (monk chanting context) or A (alpine meadow context) when combined with traffic sound can lower the anger score compared to when traffic sound was played by itself. This result indicated that C and A, as environmental factors, are appraised as none or less insulting to ego-identity compares to traffic sound. The post-hoc result also shows that TC and TA don't significantly differ in anger score ($p > .05$), which means that C and A shared similarity when appraised together with traffic sound, as the results showed that the C context also reduced the anger score when combined with fountain sound. Anger as an emotion is represented by a seemingly intentional offence towards an individual (the core relation theme of anger). The key appraisal components for the appraisal pattern of anger are goal relevance, goal incongruence (incongruence to relax), ego-involvement (where one tries to preserve or enhance one ego-identity) and accountability (where others likely the experiment conductor are to blame for the cause of damage to ego-identity).

The anger emotion in this study can be both produced explicitly or implicitly. If anger was produced explicitly, it is assumed that C or A contexts were distracting participants' attention away from traffic sound or fountain sound. Therefore, when C or A were added to traffic sound or fountain sound, people's appraisal of the environment leaned more towards the context itself rather than the sound source. Since the anger score reduced whenever the contexts were paired with the two sounds, this indicated that C context as a factor was less likely to produce anger compared to fountain and traffic sound and A context as a factor was less likely to produce anger compared to traffic sound. This assumption also implied that fountain sound and traffic sound contained certain degrees of inherent association with anger as an emotion. The assumption where the two contexts acted as a distraction in the appraisal process was evidenced by the change in the spending of cognitive resources. If conscious thinking is involved in the production of emotion, it implies that people have spent effort (cognitive resources) to appraise the environment they encountered. The change in the amount of cognitive resource spending should be reflected in fatigue and/or vigour mood scores, as these two mood categories can reflect changes in resource spending (see Section 6.4.1.5). If traffic sound and the C context in the TC group were both being appraised fully, it should logically show an increase in cognitive resource spending and be reflected in fatigue scores as an increase and/or in the vigour score as a reduction. The fact that the post-hoc test results showed a decrease in fatigue (where T has a significantly higher fatigue score than TC, this will be discussed in Section 6.4.1.5) and no significant change in vigour scores indicated a reduction in cognitive resource spending. The only logical deduction from this indication was that instead of both the sound and context being appraised, the only factor appraised (in the TC group) was the context and that it required less cognitive resources to process.

If anger is produced implicitly, it means that there is emotional memory associated with traffic and fountain sound when they are heard when people try to relax. In the TC, TA and FC groups, the decrease in anger score indicated that there was less association between the C (Monk Chanting) and A (Alpine Meadow) contexts with anger. Since this anger was triggered through emotional memory and the significant result indicated this similar memory (a completed past appraisal) was shared among participants, this collective view indicated a existence of a shared opinion among participants. Hence, fountain sound and traffic sound has an inherent connection with anger, whereas contexts such as religious setting and natural setting are inherently less likely to associate with anger.

6.4.2.2 Confusion

The post-hoc test showed that the confusion mood scores differed significantly between participant group (1) T and TC (where T has a higher mean value in anger than TC); (2) F and FTc (where F has a higher mean value in anger than FTc); and (3) F and FA (where F has a higher mean value in anger than A). The result showed C context when combined with traffic sound can lower the confusion score compared to when traffic sound was played by itself. Similar results have also shown between contexts Tc (Temple context) or A and fountain sound, where the confusion score also reduced when the contexts were combined with fountain sound. The confusion mood is not an emotion but explains a state where people cannot make a connection between their goals and the environmental encounters. If such a people-environment cannot be established, there is no emotion to begin with. Confusion situation can be latter resolved by committing cognitive efforts or dismissed as irrelevant to one's goal. The significant result of confusion only showed that confusion existed but did not show its resolve or dismission. In this experiment, emotion did form, as evidenced by the score changing in other mood categories, indicating that the human-environment connection was eventually made. In this study (Chapter 6), the participants' goal was to relax, and environmental encounter are the provided contexts and sound source. The confusion score showed a significant reduction when contexts were presented together with the sound source, indicating that there was a degree of confusion associated with the two sound sources. The reduction in the confusion score also indicated that an environment is easier to understand when presented with context and this conclusion concurred with the laymen understanding of what context does (see the discussion in Section 6.3.2).

It is assumed that confusion is produced consciously, as the confusion state itself implies that people have tried to consciously make a human-environment connection but did not succeed due to the complexity of the encounter. The logic of how emotion can be triggered through emotional memory with minimal or no conscious effort does not apply to confusion, as it is not emotion by the appraisal theory standard. Confusion is merely a state that could present at the early stage of the appraisal (emotional forming) process. Under the assumption that the confusion state results from conscious thinking, contexts appears to have provided the environmental context required for the sound sources (i.e. context C for traffic sound; and context Tc and A for fountain sound) to establish the human-environment connection that was previously difficult to establish. This deduction requires the sound sources to remain as the main factor that has been appraised within the new combinations, and the sound sources need to fit in with the newly added context. For traffic sound, it is difficult to imagine a religious context (the C context) that could associate with it. This difficulty in association means that the context C may not provide ease of understanding for traffic sound and participants, instead of appraising the more confusion traffic sound, chose to appease the easier to understand C context. In other words, the C context created a distraction in the appraisal process. For fountain sound, Tc and A can both provide a reasonable context for the sound, such as a courtyard with a water feature or an alpine meadow with a water stream. It is reasonable to assume the Tc and A context provided the required information for fountain sound to be understood. However, similar distractions in the appraisal process that appeared in traffic sound was still a possibility in the appraising of fountain sound. The only indicator that could distinguish whether the context provided information for the sound source or acted as distractions was cognitive resource spending.

As discussed in the anger Section (4.1.1), vigour and fatigue can reflect the change in cognitive resource spending. If more cognitive resource has been spent in the appraising of a context and sound source group than the sound source alone, this indicated that both the contexts and the sound source have been appraised in the appraisal process. In other words, the context provided environmental information for the sound source and should be reflected as an increase in fatigue score and/or decrease in vigour score. If the cognitive resource spent was lower in a sound source and context combination compared to sound source alone (such as between T and TC), this likely indicated that the focus of appraisal was on the context itself rather than the sound source, and that the context required less cognitive resource to appraise. Therefore, it was a distraction from the context and should reflected be as a decrease in fatigue scores and/or an increase in vigour scores. The fatigue score of participant group T was significantly higher than that of participant group TC ($p < .05$), meaning that the C context was a distraction to the traffic sound. The same evidence was also found between the fatigue score of F and FTc, indicating that Tc was likely a distraction to the fountain sound rather than providing environmental information for the sound. There were no significant differences in both vigour and fatigue scores between F and FA ($p > .05$) which could mean two things. First, that context A had no effect on appraising the appraisal process and was also not appraised. The second, that context was the focus of the appraisal process and required a similar amount of cognitive effort to appraise. The first assumption is unlikely as the significant confusion scores indicated that the A context did affect the appraisal process; hence, it is more likely that the A context also distracted attention from the fountain sound.

6.4.2.3 Depression

The post-hoc test results showed a significant depression score difference between participant group (1) T and TC (where T has a higher mean value in depression than TC); and (2) F and FC (where F has a higher mean value in anger than FC). The results indicated that C context when combined with traffic sound or fountain sound can lower the depression score compared to when the two sound when heard alone. The depression mood cannot be defined by single emotions, instead, it could lead to several potential negative emotions. This nature was represented in the POMS questionnaire with items of several emotions (i.e. sadness, fear, guilt/shame and anxiety). Despite the design of the questionnaire not allowing these emotions to be distinguished from each other, the results from the depression mood provided insight into the likeliness to produce negative emotions. Based on the post-hoc test, traffic and fountain sounds were likely to be associated with depression-related emotions when people were trying to relax. Moreover, such an association can be weakened when the context of religious chanting was presented.

6.4.2.4 Tension

The post-hoc test showed that the tension score differed significantly between participant groups T and TC (where T has a higher mean value in anger than TC). The results showed that C context when combined with traffic sound can lower the tension score compared to when traffic sound was played on its own. The tension mood category reflex emotional distress in the appraisal process consists of two appraisal components: goal relevance; and goal congruence. These two components are included in all negative emotions, therefore the significance of distress has also been reflected in other negative emotions (i.e. anger and depression score are both significantly different) between the T and TC group. The post-hoc result indicated that traffic sound was likely to cause emotional distress when people tried to relax, and such distress can be reduced through contexts such as religious chanting.

Same as other emotions, tension or emotional distress can be produced through a conscious explicit process and/or an unconscious implicit process. If distress is produced explicitly, it indicates that people have recognised the existence of such distress and are aware of is incongruence to his/her goal. In this study, it indicated that the participants recognised the interference of traffic sound towards relaxing activities in the T group. In the TC group, however, this awareness of interference was reduced by C context. This reduction was most likely due to the distraction provided by the context, as the context was unlikely to provide logical environmental information to traffic sound (see also the discussion in Section 6.4.2.2). This assumption regarding distraction was also supported by the decrease of fatigue score (from T to TC, see the discussion in Sections 6.4.2.1 and 6.4.2.2, and result in Section 6.4.2.5). If the distress is produced implicitly, it indicates there are universal emotional memories of emotional distress or negative emotions associated with traffic sound, and this kind of association is unlikely to exist in contexts such as religious chanting.

6.4.2.5 Fatigue and vigour

The post-hoc test result showed that fatigue scores significantly differed between group (1) T and TC groups (where T has a higher mean value in anger than TC); (2) T and TA groups (where T has a higher mean value in anger than TA), but there is no difference between group TC and TA; and (3) F and FTc groups (where F has a higher mean value in anger than FTc). Fatigue as a mood category is not an emotion per se, but it explains a state where the cognitive resource (effort) required to appraise an environment has exceeded the cognitive resources an individual processes. The post-hoc results indicated that traffic sound (T) or fountain sound (F) by themselves required more cognitive resources to appraise when people tried to relax. This relatively high resource requirement might partially be due to the sounds by themselves lacking context, especially when played in an indoor (laboratory) environment. This lack of context was evidenced by the significant higher confusion score in T or F group compared to TC or FTc groups (see also Section 6.4.1.2). The post-hoc test results also showed that the cost of cognitive resources to appraise traffic and fountain sound can be reduced when contexts are introduced (C or A context for traffic sound, and Tc for fountain sound, respectively). This reduction was assumed to be the result of distraction as mentioned many times in the discussion of other mood categories (see Sections 6.4.1.1, 6.4.1.2 and 6.4,1,4). The fatigue score itself was the best indication of such distraction. Logically, the more environmental context that is introduced to an appraisal process the more cognitive resource is required to appraise such an environment. This increase, when reflected in fatigue, was shown as an increase in its score. However, the comparison result of both traffic and fountain sound showed a decrease in fatigue score when combined with context C, A (for traffic sound) and Tc (for fountain sound), indicating that the cognitive resources required to appraise the environment have decreased. Assuming the cognitive resource to appraise the two sounds does not change between the groups, the only logical deduction would be that the focus of appraisal shifted towards the contexts themselves, and that the cognitive resource to appraise the contexts was significantly less than that required to appraise the sounds.

Vigour mood, on the other hand, did not show significant results between the different participant groups. However, this result did not contradict the result from fatigue. This was because despite the two states both reflecting cognitive resource spending, they are mutually exclusive. One cannot experience one when they are already experiencing the other. In the vigour state, people's possessed cognitive resource has not yet been exceeded by the requirement to appraise an environment. The insignificant result in the post-hoc test simply meant, then, that most of the participants were under the fatigue state rather than a vigorous state.

6.4.3 Appropriateness of the contexts

Aletta et al. (2016) suggested that the appropriateness of sound should be considered as an additional dimension to complement the PCM. As the current study was designed to explore the context beyond the urban setting, none of the three sound types (urban sounds) was appropriate for any of the contexts. However, certain nuances were present within each sound source.

1) Street music is normally limited to an urban public space; however, as a form of music, it is difficult to argue that such music is inappropriate for any environment, as the music is often used as an artificial background sound. For instance, one participant, in the street music group, responded to an open question as follows: ‘the well-combined music and imagery helps me to relax from my busy schedule’. Another participant stated that he ‘feels like I was there’. This feeling of appropriateness might partially help explain the lack of significant mood changes in the case of street music and the related context groups.
2) A water feature is often present in a Buddhist temple; however, such features usually produce a calming stream sound instead of a high flow rate fountain sound (as in this study). Moreover, in the alpine meadow context, the visual cue did not include any water feature, which likely contributed to the inappropriateness of the fountain sound. This aspect can help explain the significant change in the confusion score in the FTc and FA groups compared to that of the fountain sound.
3) Finally, the traffic sound was the only sound type unfit for all the contexts, as it had the most significant mood changes among the alpine meadow and monk chanting context groups.

In conclusion, the sound appropriateness likely affected the mood changes; however, the examination of this dimension was beyond the scope of this study and thus requires further exploration.

6.4.4 Requirement of more dimensions to study the mood states

The mood states used in this study can be grouped into unpleasant groups (anger, confusion, depression, tension, and fatigue) and pleasant groups (vigour) based on the desirability and benefit/drawback of such mood states. However, in terms of the eventful/activation, only anger, tension, and fatigue can be vaguely distinguished from the group. Table 6.9 indicates how the six mood states can be differentiated in terms of the pleasantness and activation based on the associated definition or description in the literature.

	Pleasantness/ Unpleasantness	**Activation/ Deactivation**	**Definition or description of the mood states**
Anger	Unpleasant	Activation	A process provoked by triggers such as a perceived threat or unfair treatment. The mood can spread and intensify in a cognitive loop. (Alia-Klein et al., 2019)
Confusion	Unpleasant	-	A mental state in which the reaction to environmental stimuli is inappropriate because the subject is bewildered perplexed, or disoriented. (Farlex Partner Medical Dictionary, 2012)
Depression (mood)	Unpleasant	-	Sadness or unhappiness, usually persistent. This may be a normal reaction to unpleasant events or the environment or may be the result of a genuine depressive illness. (Collins Dictionary of Medicine, n.d)
Tension (stress)	Unpleasant	Activation	Psychological stress is a particular relationship between the person and environment, which is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being. (Lazarus & Folkman, 1984)
Fatigue (mentally)	Unpleasant	Activation	Boksem and Tops indicated that the feeling of fatigue may result from the subconscious analyses of the cost and benefits to expend or conserve energy. (Boksem & Tops, 2008)
Vigour	Pleasant	-	In contrast to mental fatigue, vigour is the lack of cognitive activity, resulting in an energetic mental state.

Table 6.9. Correlation of the six mood states with the pleasantness and activation (eventful) dimensions, based on the definitions presented in the literature.

The two components of the core affect are somewhat interchangeable with the two dimensions of the mood/emotions, that is, valence and arousal (Russell, 2003). The valence represents whether a mood/emotion is positive or negative, and the arousal represents the intensity. Based on the definition and descriptions of the six studied mood states, it is obvious that while it is fairly easy to identify whether the mood is positive or negative (valence), it is difficult to specify where the mood should be located in terms of the intensity. For example, moods such as vigour and depression can be activating (e.g. energetic) or deactivating (e.g. calm). Moreover, although moods such as anger, tension and fatigue appear on the activation side, they can also be extremely intense (e.g. furiousness and extreme anxiety) or mild. Furthermore, moods such as confusion may be undefinable by the activation dimension. Considering these differences, dimensions in addition to pleasantness and activation/eventfulness must be examined. A reasonable starting point may be familiarity/appropriateness. This component is relatively less utilised in soundscape studies owing to its small effect; however, this component likely plays a crucial role in the interpretation of the perceived soundscape quality (Aletta et al., 2016; Jambrošić et al., 2013). For mood-related soundscape studies, these additional dimensions may vary across mood/emotion categories.

6.4.5 Application

Despite the need to expand the varieties of the studied mood categories, sound sources, and types of context, this study may provide guidance for urban planning. The results have indicated that the introduction of activities with dominant human sounds can significantly reduce negative emotions. The design of an enclosed space that obstructs the visual of the sound sources may help reduce negative emotions, although the effect seemed to be limited to the sound types and mood categories. The same limited effect can also be observed by introducing greenery. This finding suggested that the design of both enclosed environments and greenery could help improve the mood states, although large quantities of both features may have a diminishing effect. Music, however, exerted a dominant effect on stabilising the mood states, despite any contexts. Finally, changing the environmental context did not appear to induce any additional mental energy (vigour) in the visitors.

6.5. Conclusions

Certain significant trends existed among different contexts in terms of their influence on the mood states. Among the six mood states, all five negative moods (anger, confusion, depression, fatigue, and tension) were significantly affected when the contexts were combined with traffic or fountain sounds. This effect, however, did not occur in the case of street music combinations. In contrast to the negative moods, the only positive mood (vigour) was not affected by any of the contexts.

In terms of the influence of the different sound types combined with contexts on the mood score, notable differences were present across all the studied sound types. The significant changes in the mood scores were alleviated when contexts were added to the original sound sources. The specific effect for each sound type was as follows:

- Traffic sound: in the monk chanting context, all the negative moods were significantly affected, and in the alpine meadow context, only anger and fatigue were affected. Finally, the combination with the temple courtyard context did not affect any of the mood states.
- Fountain sound: in the monk chanting context, anger and depression were significantly affected, and in the temple courtyard context, confusion and fatigue were

significantly affected. When combined with the alpine meadow context, only the confusion mood state was significantly affected.

- The mood states did not show any significant difference when street music was combined with any of the three contexts.

In terms of the visual and audio stimuli, the contexts exhibited varied effects on the mood scores; however, in the evaluation of each context, no similarity was found across the contexts. The specific results for each context were as follows:

- The visual of an enclosed environment with specific features (such as a temple) did not affect the mood scores. The audio of the context (birdsong) had a significant but limited effect on fatigue and confusion when combined with the fountain sound.
- The visual and audio of a sacred place such as a temple interior context likely influenced the mood changes in terms of the perceived pleasantness.
- The visual and audio stimuli of the alpine meadow possessed a distinct natural feature, which facilitated the mood change in terms of the pleasantness.

Gender difference had a significant small (depression) to medium (fatigue) effect on the intensity of the mood change caused by the difference in the contexts and sound sources. However, the gender that exhibited a more intense mood reaction was unclear.

Moreover, the pleasantness and eventfulness dimensions could not fully explain the outcomes of the mood states in the soundscape studies. New dimensions need to be developed to further understand the mood states. It is hypothesised here that the developed dimensions may be different depending on the contexts, sound types, and mood states.

Chapter 7: Discussion

The last three chapters examined environmental stimuli (in a real urban public setting), three sound types (in a controlled environment) and non-urban contexts (in a controlled environment) and their effect on emotional outcomes, respectively. The three studies found that there was an effect of the three sound types and that environmental contexts have a significant effect on emotional outcomes. Three studies have concluded that the three sound types showed significantly differing effects on emotional outcomes, and the environmental context they reside in has a significant effect on how the sound types are subjectively perceived. Following these conclusions, this chapter then compared the results and conclusions from all three studies and examined the results using the appraisal theory. The subsequent discussion and analysis provided a systematic understanding of emotional responses within acoustic environments.

7.1 How the soundscape of urban public space affects the mood or emotions? – The first study

The first study (see Chapter 4) was set up to answer the research question: how does the soundscape of urban public space affect moods or emotions? The first study aimed to identify and examine the sound sources and environmental factors that had the potential to affect mood or emotions through a case study in Sheffield City Centre. The study also provided frameworks for the subsequent studies in this thesis. The major finding of the first study was the significant influence on emotional responses of the three sound sources: street music (from street performance); traffic sound; and fountain sound. The first study also found other environmental contexts (such as ice-cream van and street vendors) that had a significant impact on mood and emotions. However, as the study was an onsite survey, the results were concluded from the statistical data where other sound sources could not be eliminated when examining a particular sound, resulting in the partial control of environmental conditions.

Although this situation did not revoke the validity of the results, it is still important to compare the result with the study with controlled environments (i.e. the second study in Chapter 5 and the third study in Chapter 6).

7.1.1 Street Music (popular music)

Before discussing the effect of street music, it is important to clarify that the street music stimulus was recorded on a pedestrian street in Sheffield City Centre, and the music types were all relatively fast tempo popular music. Whether the conclusions of this research can be extended to other music types will require further study.

In the first study, street music was found to be eventful and pleasant, and when presented it took a dominant position within the public space. Street music had a significant negative effect on anger, confusion, depression, fatigue and tension mood categories, indicating that the above mood or emotions reduced in intensity when street music was presented. Such reductions in negative emotions and calming effects have also been observed in other music-related studies. In Krahé and Bieneck's (2012) study, it was found that if the type of music (classical music to be specific) was appraised as pleasant, it could effectively reduce anger in listeners. In Theorell and Bojner Horwitz's (2019) study, classical music has also been shown to significantly increase the calmness score (alone an anxious to calmness visual scale) of their listeners. Music types other than classical were also observed to reduce negative emotions or increase calming mood in McCraty, Barrios-Choplin, Atkinson and Tomasino's (1998) study of emotional effect of several music types. McCraty and colleague found that non-classical music, such as new age music and designer music also reduces tension mood effectively for adults. Additionally, their finding also suggested that these two types of music were also effective in reducing hostility (anger) for adults and increasing relaxation mood for both adults and teens. Despite these previous study findings supporting the results of the first thesis study, they also contain results that are different. These differences could be due to several factors.

Age difference is one major factor that has been shown to significantly influence emotional responses toward music listeners among previous studies. In both Theorell and Bojner Horwitz's (2019) and McCraty, Barrios-Choplin, Atkinson and Tomasino's (1998) study, comparisons were made between younger and adult listeners. Both studies showed a similar trend with adults appearing to be more susceptible to emotional changes after listening to music. See Table 7.1 and Table 7.2 for emotional response comparison between age groups in previous studies.

Type of music	Age groups	Joy	Calmness
Classical music	**Children group 1** (9-12 years old, mean age 10.4)	NS	Sig-Inc
	Children group 2 (13-15 years old, mean age 13.9)	Sig-Inc	NS
	Adult group (22-70 years old, mean age 44.8)	Sig-Inc	Sig-Inc

Table 7.1 Significant results comparison between age groups (Theorell & Bojner Horwitz 2019)
Music played: Beethoven's string trio, in G-major, op 9 number 1; and the Serenade for string trio by Ernst Dochnanyi op 10
NS = No significant change after music listening
Sig-Inc = Significantly increase after music listening

Type of music	Age groups	Caring	Mental clarity	Relaxation	Vigour	Hostility	Fatigue	Sadness	Tension
Grunge rock music	**Teenage** (12-17 years old, mean age 14)	Sig-Dec	Sig-Dec	Sig-Dec	Sig-Dec	Sig-Inc	NS	NS	Sig-Inc
	Adult (25-76 years old, mean age 46)	Sig-Dec	Sig-Dec	Sig-Dec	Sig-Dec	Sig-Inc	Sig-Inc	Sig-Inc	Sig-Inc
Designer music	**Teenage** (12-17 years old, mean age 14)	NS	NS	Sig-Inc	NS	NS	NS	Sig-Dec	NS
	Adult (25-76 years old, mean age 46)	Sig-Inc	Sig-Inc	Sig-Inc	Sig-Inc	Sig-Dec	Sig-Dec	Sig-Dec	Sig-Dec

Table 7.2 Significant results comparison between two age groups (McCraty, Barrios-Choplin, Atkinson & Tomasino, 1998)
NS = No significant change after music listening
Sig-Inc = Significant increase after music listening
Sig-Dec = Significant decrease after music listening

This weaker reaction from children and teen groups after music listening partially explains why the significant emotional responses in the first thesis study were absent in the second and the third. As in the first thesis study, participants' age range was 14 to 75 (mean = 31.56), including a large portion of adults. In contrast, the age range of the second and third thesis studies fell within the age of range of teenagers and young adults: 18 to 23 (mean = 20.31) and 17 to 25 (mean = 19.21), respectively.

The other major factor shown in the past study that had a significant effect on emotional responses after music listening was music type. Among the different types of music examined here, the effect of popular music used in the first thesis study includes designer music used in

McCraty and colleague's (1998) study. Table 7.3 shows the result comparison between the two studies.

Studies	Emotional dimensions[1]	Mental clarity	Vigor	Hostility	Fatigue	Sadness	Tension
Study from McCraty, Barrios-Choplin, Atkinson and Tomasino (1998)	Adults emotional response after listening to designer music	Sig-Inc	Sig-Inc	Sig-Dec	Sig-Dec	Sig-Dec	Sig-Dec
The first Thesis study	Adults emotional response after listening to popular music	Sig-Dec	NS	Sig-Dec	Sig-Dec	Sig-Dec	Sig-Dec
	Emotional dimensions (POMS)[2]	**Confusion[3]**	**Vigor**	**Anger**	**Fatigue**	**Depression**	**Tension**

Table 7.3 Emotional response comparison between two types of music (in previoues study and the first thesis study)
1: Dimensions of 'Caring' and 'Relaxation' where not shown in this table as there are no matching emotional dimension in POMS
2: profile of mood states (POMS)
3: 'Confusion' is a reversed dimension when compares to 'mental clarity'
NS = No significant change after listening music
Sig-Inc = Significant increase after music listening
Sig-Dec = Significant decrease after music listening

Table 7.3 shows that most of the emotional dimensions in McCraty and colleagues' (1998) study, after listening to designer music, had an identical emotional response when compared to the first thesis study. This comparison indicated that designer music shares a similar musical characteristic with popular music. Both music factors in the past studies showed that the result obtained from street performance (popular music) has limited application. The effect of music on listeners both depends on the music type and age difference of the listeners. Hence, the result of popular music in the first thesis study only served to investigate the underlying mechanics of sound types (including street music) on perceivers. The results cannot be generalised to music types and age groups beyond non-aggressive music (such as popular music and designer music) and adults.

In the second study (Chapter 5), despite the audio clips that contained popular music significantly affecting moods and emotions, the result concluded that the significant change was not caused by the popular music. The significant difference was a result of the absence of the other two sound sources (traffic sound and fountain sound). The difference in the results between the first and the second studies was assumed to be caused by the contextual difference between the two studies. The first study was conducted on-site where the popular music was live performed; however, in the second study, the popular music stimuli were merely a recorded replay from the same performance. This lack of performance would largely remove the eventfulness of stimuli. The difference between the on-site popular music and laboratory replay would be like the difference between listening to a music record and attending and listening to a live music concert. The difference between live music and recorded music and its effect on mood was also found in other literature. Bailey (1983) experimented on 50 cancer patients to see how their mood changed after listening to live music or a recorded replay. The results indicated that live music had a significant effect on relieving tension and promoting vigour compared to recorded music. It was also believed that the human interaction between performers and pedestrians was crucial to this difference. Another study that examined emotional response to classical music in different age groups (school children, adults and the elderly), also found that the strongest positive reaction to music was found in live performance rather than recorded music (Theorell & Bojner Horwitz, 2019). This difference between live music and recorded music was not only found between the first study (Chapter 4) and the second study (Chapter 5), but also found within the first study itself. Within the first study, two types of music were observed: street performance; and recorded music played in the street side stores. Comparing the street performance's effect on reducing multiple moods' scores, the store music only had a significant effect on tension and the effect itself increased the tension score. There was a clear weaker effect in the store music compared to live performance street music.

With regards to the eventfulness of the street music, it also showed a close relationship with ‘distraction’, that was frequently mentioned in the decision section in the second (Chapter 5) and third (Chapter 6) studies. In the PCM, the eventfulness dimension implied that any environmental factors that rated high in this dimension were likely to attract attention and likely to become the focus of an individual observing an environment. The distraction that was discussed in the second and third studies explained a similar situation, where the attention of participants shifted to factors exhibiting standout (interesting, complex or ambiguous) from within the context of the stimuli groups. People, then, were more likely to appraise such eventful (distracting) factors within an environment, in which case cognitive resource (conscious effort) would be spent on these factors instead of others. In the current study, such eventfulness can be indicated by mood fatigue and vigour, as both moods explain a state where there is an imbalance between a cognitive resource that one possesses and the amount of cognitive resource required to appraise an environment. This difference in eventfulness was clearly shown between street music and store music (within the first study, see chapter 4). Street music was associated with a decrease in fatigue, indicating that less cognitive resource was spent, whereas store music was not associated with a significant change in either the fatigue or vigour moods, indicating that cognitive resources used to appraise the environment had not been significantly changed with the presence of store music.

In the third study, the mood score of anger and tension in the street music (recorded) group was significantly lower than in the traffic sound group, and similarly, the tension and confusion scores in the street music group were significantly lower when compared to the fountain sound group. There was a consistency in the street music’s association with a low intensity of tension and other negative emotion. This result was consistent with the first study (Chapter 4). In the second study, each sound stimulus was mixed with 2 or 3 sound types. Although the comparison was made between the sound sources (street music, traffic sound and fountain sound), the results relied on other sound sources within the same acoustic stimulus which were not included in the comparisons to be seen as part of the controlled environment. In the third study, however, these comparisons between the sound sources were made one-on-one, which may also partially explain why the significance in street music was shown in the third study but not in the second study (see Table 7.4).

Table 7.4 Post hoc analysis between sound types in the third study

		M v T	M v F	T v F
Games-Howell	Anger	-13.640***	-10.560	3.080
Games-Howell	Fatigue	-6.040	-5.480	0.560
Games-Howell	Tension	-12.200***	-9.880*	2.320
Bonferroni	Confusion	-6.040	-7.280**	-1.240
Bonferroni	Depression	-9.440	-9.560	-0.120
Bonferroni	Vigour	-3.480	-4.800	-1.320

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$
M = Street Music
T = Traffic sound
F = Fountain sound
The use of Games-Howell tests were for the groups that has equal population variance
The Bonferroni tests were used as default for the controlling of type I error

The lower score of tension in the street music groups indicated that street music (popular music) was associated with low emotional distress. This was also found in other studies, such as tension relieving and vigour promoting with popular music (Bailey, 1983) and anger reducing with pleasant music (Krahé & Bieneck, 2012). The third study aimed to examine the non-urban contexts and their effect on mood or emotion in soundscapes. For street music specifically, neither of the contexts (temple courtyard, monk chanting and alpine meadow) had any significant impact on the mood states. This result again proved that street music was less associated with negative mood or emotions. As shown in the third study, all three contexts had different degrees of reducing effect on negative emotions when combined with traffic sound or fountain sound, indicating that these contexts were less associated with negative mood or emotions. That there was no significant impact on any mood scores when these contexts were combined with street music indicated that street music itself also had less association with negative moods or emotions.

7.1.2 Traffic Sound

In the first study, it was concluded that the insignificant effect of traffic on mood or emotions was due to the participants' (urban dweller) familiarity with the urban environment. Traffic as a common environmental factor in an urban setting is uneventful, especially in places like the city centre in the case study. Therefore, in situations where participants consciously appraised the environment, traffic sound was not the focus of the appraisal processes; instead participant attention was focused on other environmental factors that did not immediately fit in the urban contexts at the first encounter, such as street music, ice-cream van and street vendors. It is important to point out that this does not mean that these factors are not common in urban spaces, but they may not be immediately associated with a mental image of an urban environment. The other situation that this result explained is that of an unconscious reaction towards traffic sound. In this case, the result indicated that traffic sound was not associated with any emotional memories that were significantly different from participants' neutral (emotional) states.

In the second study, however, the traffic sound showed significant effects on moods and emotions, specifically in the anger, tension, confusion and fatigue mood categories. Past study has shown similar result in terms of a negative evaluation of traffic sound (See result comparison in Table 7.5).

Experiment environment	Studies that contains traffic sound	Results of traffic sound listening
Laboratory	Second thesis study	Significant higher in *anger*, **tension**, **confusion** and **fatigue** compared to other sounds[1]
	Third thesis study	Significant higher in **anger** and **tension** compared to other sounds[1]
	Study of Alvarsson, Wiens and Nilsson (2010)	High traffic noise[2] has the lowest ***pleasantness*** rating and highest ***eventfulness*** rating among other sounds[3]
Urban green space (in-situ)	First thesis study	No significant effect on any emotional category[4]
	Study of Kogan, Arenas, Bermejo, Hinalaf and Turra (2018)	The overall soundscape assessment (OSA) of traffic sound is **neutral** to **slightly bad**
	Study of Rey Gozalo, Barrigón, Juan, Montes, David, Atanasio and Pedro (2018)	Appraised as **annoying** compared to other sound[5]
	Study of Szeremeta and Zannin (2009)	Appraised as **unpleasant**

Table 7.5 Results comparison of listening to traffic sound among previous studies and thesis studies
1: Other sounds include street music (popular music) and fountain sound (high flow-rate)
2: High traffic noise (80dB, LAeq, 4min)
3: Other sounds include nature sounds (50 dB, LAeq, 4min), low traffic noise (50dB LAeq, 4min) and ambient noise (40dB, LAeq, 4min)
4: Emotional categories include anger, depression, tension, confusion, fatigue and vigour
5: Other sounds include construction, screams, animals, maintenance, children and water

Result of traffic sound from second study is differed from the first study. This difference in the result was assumed to be the contextual difference between the two studies. The first study was conducted in a real urban environment, whereas the second study was conducted in an indoor laboratory setting. Although the laboratory was designed to simulate the acoustic condition of the same outdoor environment (in terms of reverberation time), the laboratory could not recreate the holistic experience of urban space, such as immersive visual and human interactions. Interestingly in previous studies when such in-situ and laboratory comparisons were made, assumptions of the influence of differing contexts appears to be false. Alvarsson, Wiens and Nilsson (2010) investigated several sounds (Natural sound, High traffic noise [80 dB, Laeq, 4 min], low traffic noise[50 dB, Laeq, 4 min] and ambient noise) and their effect on stress recovery in a laboratory environment, and found that high traffic noise had the lowest rating on pleasantness and highest rating on eventfulness. This results is in agreement with other in-situ studies (Kogan, Arenas, Bermejo, Hinalaf & Turra, 2018; Rey Gozalo, Barrigón, Juan, Montes, David, Atanasio & Pedro, 2018; Szeremeta & Zannin, 2009). This shows that environmental context differences may not be the reason traffic sound is appraised differently, but is due to some other key dimensions (see comparison also in Table 7.5). Upon closer examination, the difference in traffic sound evaluation may be caused by the appropriateness of the context (in relation to the sound). Result of in-situ studies showing an unpleasant or annoying perception of traffic sound (Kogan et al., 2018; Reyet al., 2018; Szeremeta & Zannin, 2009) were all conducted in environments such as urban parks or green spaces. An environment like an urban park lacks direct association with traffic sound and may be considered as inappropriate to the environment of an urban park. Hence, significant reactions were produced when both were appraised together. This notion of appropriateness has also been examined and discussed in a study regarding the effect of context on urban settings (Hong, Lam, Ong, Ooi, Gan, Kang, Yeong, Lee, Tan, 2020). The contextual difference between the first and the second thesis study caused the traffic sound to stand out from its context (the laboratory). In other words, the traffic sound became eventful in the second study (laboratory setting) and became the attention of the explicit appraisal process. Hence, a significant result was produced. If the traffic sound in the second study was processed unconsciously (implicitly) by participants, the significant result indicated that the contexts and eventfulness of a sound could also be memorised by emotional memory and become part of the criteria to trigger the automatic emotional response related to that memory.

The traffic sound in the third study showed a significantly higher anger and tension mood score compared to street music (see Table 7.1). This result again showed a similar difference resulting from the contextual differences between urban and laboratory environments. The focus of the third study was to examine the contexts and how would they influence emotional outcomes. The result showed that different contexts indeed showed a different effect on emotional outcomes. The monk chanting (C) contexts (simulated) combined with traffic sound showed a significant difference in affecting anger, tension, confusion, depression and fatigue ($p < .05$) compared to the urban context (simulated). The Alpine meadow (A) context (simulated) also showed a significant difference in anger and fatigue. Both contexts supported the conclusion that the resultant differences between the first study and second or third studies in traffic sound was caused by the contextual difference between urban and laboratory contexts.

7.1.3 Fountain Sound

Before discussing the fountain sound, it is important to clarify that the fountain sound used in all three studies are of the same high flow-rate fountain. In contrast to many previous studies, the fountain sound in this thesis was not perceived as pleasant by participants (Pérez-Martínez et al., 2018; Yang & Kang, 2005a, 2005b), improved the evaluation of soundscape (Jeon et al., 2010) nor did it produce any stress recovery effect (Alvarsson et al., 2010). However, evidence from previous studies have shown that fountain sound can be negatively perceived (Galbrun & Ali, 2013; Jeon, Lee, You, & Kang, 2012; Rådsten-Ekman et al., 2015). Particularly, Rådsten-Ekman and colleagues (2015) found that the high flow-rate fountain sound that was similar to the sound used in the thesis could produce a steady-state sound that was found to be unpleasant compared to other types of fountain sound.

The first study showed that the fatigue mood score was significantly higher in fountain sound than in other sounds sources that were found in the case study. Fatigue mood category was an indicator of the cognitive resource required to appraise an environmental encounter, and it was found to be higher than the cognitive resource that an individual possessed. The higher the score, the larger the difference between the two. This significant higher fatigue in the result indicated that the steady-state sound produced by the fountain required significantly more cognitive resource to appraise when participants were fatigued. As mentioned above, this was related to the unpleasant nature of high flow rate water fountains. This high rating in fatigue also meant that the fountain sound attracted more attention compared to other sound sources when participants were fatigued.

A similar high requirement of cognitive resource in fountain sound was also found in the second study. When fountain sound was removed from the combination of street music, traffic sound and fountain sound, a significant decrease in fatigue mood was shown. This indicated that the fountain sound indeed increased the cognitive effort required when participants were fatigued. A noteworthy point is that when participants were in a vigour state, the vigour score increased with the presence of fountain sound, indicating that the cognitive resource requirement was different between fatigue and vigour for the fountain sound. However, in the third study, there was no direct association between the fountain sound and the change in cognitive resource spending. The only association with a potential change in the requirement of cognitive resource was that the confusion mood score was rather higher in fountain sound than in street music (see Table 7.4). The confusion state explains a situation where a person cannot make sense of the environmental encounter and the human-environmental encounter cannot be established at the moment of the confusion. There are two likely outcomes for confusion, the first is the environmental encounter is being dismissed, which means no emotion would be produced. The second outcome is that the perceiver of the encounter spent extra cognitive resources to establish a believable human-environment relationship so an emotion may be produced. The potential in cognitive resource change in the third study lay with the second outcome following a confused state. However, the result indicated that listening to fountain sound alone in the context of the laboratory was insufficient to encourage participants to make the extra effort to establish a human-environmental relationship. This outcome was achieved with the presence of other contexts. This was proved by: 1) the significant reduction in confusion and fatigue when fountain sound was combined with the temple courtyard context; and 2) the significant reduction in confusion when fountain sound was combined with the alpine meadow context.

7.1.4 The Environmental Contexts

It was concluded in the first thesis study that the contexts of natural factors, namely daylight and temperature, did not significantly affect the moods or emotions, due to the changes in both factors during the case study being subtle. This result did not affect the second and third study as they were not the focus of the thesis, and could easily be controlled in the laboratory environment. The non-natural contexts in the first thesis study (i.e. ice-cream van and street vendor), however, significantly affected the outcomes of moods and emotions. Both factors only provided visual stimulation for participants rather than acoustical stimulus. The ice-cream van had a significant negative relationship with confusion, depression and tension and a significant positive relationship with vigour. The street vendor had a significant negative relationship with confusion, fatigue and tension. These results explain two possible ways of reacting to the contexts: the explicit conscious way; and the implicit unconscious way. Explicitly, the ice-cream van and the street vendor could both be appraised and establish a meaningful human-environment relationship with participants. The emotional responses produced through this relationship were likely to be positive (i.e. low association with negative mood or emotions high association with positive mood or emotions). If the reaction were implicit, both contexts were likely to associate with positive emotional memories, hence triggering a positive emotional response. As both contexts were associated with recreational activity (i.e. shopping and dessert) and likely to be associated with a pleasant memory or appraised as positive at the moment, this makes both ways of reacting to the two contexts highly likely.

The other finding that the result indicated was that contexts have the potential to distract the attention from other environmental factors within the same environments. This was indicated by the significant positive association with vigour in the ice-cream van and the significant negative association with fatigue in the street vendor. This hypothesis on the ability of contexts to distract was subsequently proved in the third study. Three contexts (temple courtyard, monk chanting and alpine meadow) remote from the urban context were selected in the third study. They were combined with the three urban sounds found in the first (case) study. The result showed a decrease in fatigue when they were combined with traffic sound and fountain sound, indicating an attention shift from the sound to the contexts.

7.2 How sound types affect mood and emotions in urban contexts? – the second study

The second study aimed to examine the three main sound types found in the first study in a controlled environment (laboratory). To simulate the acoustical condition of the onsite study, three sound types were mixed into 4 sound clips (3 sound clips of two of the sound types and 1 sound clip of all three sound types). The performance of any single sound type was observed under the control of the other two sound types. The design of the sound clips (stimuli) in the second study shared similarity with the first (case) study, as all types of sound were mixed. The difference in the second study was that when analysing a sound type, the other sounds and physical environment were completely controlled, whereas in the first study, the environment and sound types could only be relatively controlled due to the limitation of a case study. The controlled environment of the second study produced more reliable results in how sound types influenced mood and emotion in an environment containing multiple sounds.

7.2.1 The Street Music in Sound Type Combinations

Through the examination of the sound type combinations, the second study concluded that street music was not very effective in affecting the moods or the emotions. This ineffectiveness was partially explained by the laboratory contexts and use of recorded music as discussed in the last section (see Section 7.1.1). This was also confirmed in the third study. In the third study, three contexts that were remote from the urban environment (i.e. temple courtyard, monk chanting and alpine meadows, all containing unique acoustic stimuli within each of the contexts) were examined by combining them with street music, traffic sound and fountain sound. It was shown that the three contexts had various degrees of effect on reducing the negative mood and emotions when combined with traffic sound and fountain sound. However, when street music was combined with the three contexts no significant result was found. This indicated that the ineffectiveness found in the second study for recorded music not only applied to fountain sound and traffic sound but also extended to other acoustical stimuli.

Additionally, the third study concluded that the reduction in negative mood scores when contexts were combined with traffic and fountain sound was caused by distraction rather than a reducing effect. In other words, instead of the traffic or fountain sound being appraised, the contexts were the focus of the appraisal process. This indicated that the three contexts had a low association with negative moods and emotions. Following this conclusion, the insignificant result of street music and contexts combination indicated that street music also had a low association with negative moods and emotions. This deduction helps explain why in the second study when street music was removed from the combination of the three sounds (street music, traffic and fountain sound), there was no significant difference in moods and emotions because removing the low negative emotion association factor (the street music) from the combination of high negative emotional association factors was less likely to result in any significant impact on said negative mood or emotion.

7.2.2 The Traffic Sound and Fountain Sound in Sound Type Combinations

In the second study, the traffic sound and fountain sound had a similar effect on moods and emotions. This was indicated by the non-significant result when either of them were combined with street music. The significant finding in traffic and fountain sound was found when they were combined with each other. When the traffic and fountain combination was compared to either one of their street music combination counterparts (i.e. the street music with traffic or fountain sound), significantly higher anger and tension scores were observed in the traffic and fountain combination. Furthermore in the combination of all three sound types, by removing either one of traffic or fountain sound, a similar change in anger and tension scores were observed (in this case they decreased). Additionally, confusion and fatigue scores were also observed to decrease following such removal. The results indicated that anger and tension were somewhat inherent in association with fountain sound and traffic sound, especially because tension was an indicator for emotional distress. The significant changes in confusion and fatigue, however. appeared to be the result of a combination of the traffic and the fountain sound. What confusion and fatigue have in common are that they both have important roles in spending of cognitive resources during an appraisal (emotional forming) process. For confusion, one of the two outcomes that followed a confusion state was the spending of more cognitive resource to resolve the confusion (the other outcome was to dismiss the situation, leading to no appraisal taking place). For fatigue, the change of its intensity indicated a change in cognitive resource, namely that cognitive resources had been spent in a state where the cognitive resource requirement to appraise an environment exceeded the cognitive resource a person possessed. On the surface, the result appeared to indicate that as the number of sound types increased, the amount of cognitive resource required to appraise such acoustic environment also increased. This was proved to be not necessarily the case by the third study.

In the third study, three contexts (with visual and audio) were implemented to determine their influence on moods and emotions when combined with each of the three sound types in the second study. Each context contained its own acoustic stimulus with dominant sounds, namely bird song for the temple courtyard context, chanting for the monk chanting context and the insect sound for the alpine meadow contexts. When each of the contexts was combined with street music, traffic and fountain sound, the sound stimulus of the context also combined with the three sound types. Therefore, the result of such a combination not only reflected the effect of the contexts but also partially the effect of the acoustic stimulus of the contexts. With the increase in sound type combinations, no significant universal change in cognitive resource spending (i.e. fatigue and confusion) was found. Instead, the change in cognitive resource varied case by case. In the fountain sound combinations, the combination of: a) the bird song showed a decrease in cognitive resource spending (indicated by a reduction in confusion and fatigue); b) the insect sound showed a potential decrease in cognitive resource requirement (indicated by a decrease in confusion scores); and c) the chanting did not show any change in cognitive resource requirement but a significant decrease in emotional distress (indicated by a decrease in anger and depression) (see also Table 6.4). In the traffic sound and contexts combinations: a) the bird song combination did not show any significant difference in cognitive resource requirement nor did it show any significant effect on any moods or emotions; b) the insect sound combination showed a significant reduction in cognitive resource requirement (indicated by a decrease in fatigue);

and c) the chanting combination also showed a significant reduction in cognitive resource requirement (indicated by a decrease in fatigue and confusion) (see also Table 6.4). From the results of both fountain and traffic combinations with contexts, three aspects were confirmed that could influence the outcomes of requirements. The first aspect was the eventfulness (dominance or ability to distract attention) of each sound types within a combination. In the results, the less dominant natural sounds (bird song and insect sound) were more effective in reducing cognitive resources when combined with fountain sound than in traffic sound. This was likely because traffic sound was more dominant in a sound combination than fountain sound. Therefore, it was more likely for bird song and insect sound to affect fountain sound instead of traffic sound. The second aspect was the qualitative nature of the sound itself (i.e. perceived as being pleasant or unpleasant). When the chanting sound was combined with the natural sound of the fountain there was no significant influence on cognitive resource requirement (indicated by no significant change in fatigue). However, when chanting was combined with traffic sound, a significant change in cognitive resource requirement was shown, likely because the fountain sound as the natural sound was perceived as more pleasant (Rådsten-Ekman et al., 2013) and required less cognitive effort to appraise. In contrast, traffic sound was often perceived as unpleasant (Kogan et al., 2018; Szeremeta & Zannin, 2009), and was more likely to be affected by a pleasant sound of human activity (Axelsson et al., 2010). The third aspect concerned the appropriateness of a sound within a combination. The bird song and insect sound were more appropriate logically when combined with fountain sound (water sound), whereas the human sound (chanting) was more suitable with traffic sound, creating a mental image of a city. In other words, when the sounds provided a logical context for each other (less confusing to understand the environment), they were more likely to reduce cognitive resource requirements to appraise the sound combinations. The three aspects were concluded to be similar to the three dimensions (eventfulness, pleasantness and familiarity) developed by Axelsson et al. (2010) in the PCM. This not only provided validity for the conclusion, it also consolidated the fundamental nature of the three emotional dimensions within the study of the soundscape.

The three aspects that were concluded to affect the cognitive resource requirement applied to the case where a small number of sound types existed in an environment. However, in an extreme case, for example, a large number of sound types are all presented at the same times, where the acoustic stimulus is moving towards white noise. It would be extremely difficult to identify one sound from the others. Indeed, it is likely to create a very confusing acoustic stimulus and the cognitive resource required to appraise such an environment may be very high. Under this condition, the effect of the three aspects (dominance of the sound, quality of the sound and the appropriateness of the sound) would be insignificant. Further, it would be difficult to predict in this case whether the indicators of cognitive resources such as fatigue and vigour would be extreme or the noise like acoustic stimulus would be dismissed altogether.

7.3 How would environmental context affect mood and emotions? – the third study

7.3.1 Effect of environmental context on emotions

The third study concluded that the three contexts that were remote from the urban environment (i.e. temple courtyard, monk chanting and alpine meadow) showed a different degree of effect on mood and emotion outcomes when combined with the three urban sounds (i.e. street music, traffic sound, and fountain sound). Where the traffic sound was shown to be affected the most by the contexts, the fountain sound affected fewer mood and emotions compared to the traffic sound, and lastly, the street music was affected at all. Although the contexts were selected based on the remoteness of the contexts from an urban environment, the remoteness does not imply physical distance, but the environmental information that was contained. In the third study specifically, the remoteness is the visual and acoustical difference.

When looking into individual mood categories from the POMS questionnaire, only anger and tension were distinct emotions. Mood categories such as depression represent a collective emotion, in itself a precursor that could lead to other negative emotions and categories such as fatigue, vigour and confusion. Fatigue, vigour and confusion have more to do with the spending of cognitive resources during an emotional process instead of emotion itself. The result of the third study clearly pointed out that when the context was not appropriate to the sound, it was likely to affect emotions such as anger, tension and depression in the study. An inappropriate example in the third study, such as when traffic sound was combined with monk chanting or alpine meadow, had a clear and significant emotion difference (specifically anger, tension and depression see also Table 6.4) compared to when traffic sound was combined with a relatively appropriate context such as the temple courtyard. A similar difference was also observed between fountain sound and the context combinations. As fountain (water) sound was a natural sound, logically it was more appropriate when combined with temple courtyard and alpine meadow compared to when combined with monk chanting. The result showed that the emotion (specifically anger and depression) change appeared in the fountain sound and chanting combination but for the other two more appropriate combinations the significant change was only on the cognitive resource spending (indicated by the changing of fatigue and confusion scores, see also Table 6.4). The emotional responses (specifically anger, tension and depression) in the third study were consistent with the previous two studies (see also Table 7.1), where the traffic sound and fountain sound had a high association with anger and tensions and street music had a low association with anger and tension.

7.3.2 The effect of environmental context on cognitive resource requirement

The finding beyond individual emotions of the third study concerned the change in cognitive resource requirements. As discussed in the previous section (see Section 7.2.2), the cognitive resource requirement to appraise a sound was dictated by the dominancy of the sound, the subjective quality of the sound and the appropriateness of the sound. The same can be applied to any environmental encounters. The three aspects share similarity to the three emotions dimension (i.e. pleasantness, eventfulness and familiarity) developed by Axelsson et al. (2010) in the PCM. The relationship between cognitive resource and the three aspects is similar but slightly different to the relationship between the emotions and three emotional dimensions. In the PCM, the three emotional dimensions represented the three aspects of the acoustic quality of soundscape and these qualities, in turn, affect and represent emotional outcomes, in other words, the combination of different intensities of three dimensions can be treated as a prototype model of any emotion. This representation is possible due to the precursor of the PCM - Russell's Core Affect model (2003), a prototype model for emotions developed based on the psychological construction of emotion. Cognitive resources, on the other hand, although affected by the three aspects of the environment (i.e. the dominance, the subjective quality, and the appropriateness of the encounter), the spent or required cognitive resource to appraise an environment cannot be represented by the same three aspects but only be affected by them. This difference between the two relationships (the emotion and the three emotional dimension and the cognitive resources and the three environmental aspects) indicated a disassociation between the emotional response and cognitive resource requirements from an environment. In other words, the change in cognitive resource requirements can be associated with emotional outcomes, but they can also appear independent from any changes of the emotions.

Several different situations could happen regarding the change of cognitive resource requirement when appraising environmental encounters with multiple environmental factors. Using the third study (Chapter 6) as an example – the combination of sounds (i.e. the street music, the traffic sound or the fountain sound) and the contexts (the temple courtyard, the monk chanting or the alpine meadow) could have resulted in several different appraisal situations. The first situation is when the appraisal of the first factor is shifted to the second one. This means that the second factor is more dominant than the first one. As the results depended on the cognitive resource required to appraise the context, the cognitive resource spent could be lower, the same or higher than when there was only the sound. And the indicator for cognitive resource requirements' fatigue, vigours or confusion score also changed accordingly. This type of situation was shown in the third study when the traffic sound was combined with the monk chanting context (where the emotion scores of anger, tension and depression decreased together with the fatigue and confusion scores) or alpine meadow context (where the anger score decreased with the fatigue score). This was similar when the fountain sound was combined with the monk chanting context (where there was no score change in fatigue, vigour and confusion, instead only a reduction in anger and depression scores) (see also Table 6.4 for the examples).

The second situation is when the factor is adding the context to the first one, meaning that the two factors are both being appraised. This should increase fatigue, confusion and/or decrease vigour scores. This situation was shown in the second study when traffic sound was added to the street music and the fountain sound combination, where the confusion and fatigue score increased accompanied by increased anger and tension scores. The same also happened when fountain sound was added to the street music and the traffic sound combination[2] (see Table 5.5 for the example).

The third situation is when the second factor is added to the first factor. This did not significantly affect the overall appraisal of the environment, meaning the first factor remained as the dominant factor. In this situation, both emotional response and cognitive resource should not change significantly as the newly added second factor was not the focus of the appraisal. This was illustrated by an example from the third study: when the street music was combined with all three contexts, no significant change was observed in both emotion and cognitive resource requirements (see Table 6.4 for the examples).

The fourth situation is when the second factor is similar to the first factor, resulting in the two factors being appraised as one unified factor. In this situation, logically, the cognitive resource requirement should remain the same, but emotion maybe change in intensity but not switch to different emotions. This situation was observed in the second study when the street music and fountain sound combination was compared to the fountain sound and traffic sound combination. As concluded, the street music in the second study did not significantly affect the emotional outcomes, and the comparison essentially added the traffic sound to the fountain sound. The result showed an increase in anger and tension scores (see also Table 5.5 for the example). In the third study, when the fountain sound as a natural sound was combined with the context of natural elements such as temple courtyard (containing bird song as the dominant sound) and alpine meadow (wherein both combinations there were no emotional changes but a reduction has shown in cognitive resource requirement indicated by

[2] In this second example, the vigour score also increased where logically it should have decreased. However, this does not prove the assumed situation was incorrect, as the change in vigour and fatigue was independent from each other, and it only showed that the cognitive resource requirement was different in the fatigue state than in the vigour state.

reducing fatigue and confusion scores) the confusion mood score were significantly reduced. This result reconfirms that when context (natural) and environmental factors (natural sound of water) are suitable to each other reduces possibility of confusion and hence less potential cognitive resource spending (see also Table 6.4 for the results).

However, similar factors did not always result in this situation. As shown in the similar comparison in the second study when the street music and traffic combination was compared to the fountain sound and traffic sound combination (essentially adding fountain sound to traffic sound), in addition to increased anger and tension scores, the vigour score also increased. This indicated that when similar factors were combined, it was also possible to reduce the cognitive resource required to appraise an environment.

The aforementioned situations were concluded based on the logic of dominancy between environmental factors. As the number of environmental factor increased, the situation became increasingly complex, but it should be possible to follow the same logic applied in the above situations to decide which factor was the more dominant in an environment. Using an example from the third study , the comparison between traffic sound and combination traffic sound and monk chanting context showed a reduction in anger, tension and depression when the context was added. This indicated that the traffic sound had some inherent association in the three moods and emotions. However, it was unclear whether this reduction was caused by the reduction effect of the context or a result of the shifting focus to the context and the context just happening to have an inherently low association with the three moods and emotions. Since the results in comparison also showed a reduction in fatigue and confusion, it indicated that the cognitive resource was reduced overall after introducing the contexts, meaning that the two contexts cannot both have been appraised (as it would either increase the cognitive resource spending or the two contexts need to be very similar), hence it suited the first situation where the added context was more dominant than the traffic sound, with the reduction effect a result of a shift in focus to the context. However, one likelihood could be that when a large number of factors are involved, it is impossible to distinguish the dominancy of an individual factor from the others within an environment.

There is one situation that does not follow the logic where the dominancy of the environmental factors attracted more attention. This situation concerns where there is no emotion produced, but the cognitive resource has been spent. This situation could be explained by the observer who spent effort and tried to understand a confusing environment but gave up before reaching any conclusion (emotional outcome). If illustrated in the same statistical data in this study, there should be only fatigue, vigour and confusion changes (as they are an indicator for cognitive resource change) but no emotional change (as in anger tension and depressions). This type of pattern in terms of statistical results was seen in the third study when fountain sound was compared with its combined with temple courtyard context or alpine meadow context. However, the two comparisons were not examples of the situation as both cases only indicated no change in the emotions but not the indication of no emotion having ever been produced. The studies in the current thesis did not replicate this situation, but nevertheless the possibility should not be neglected.

The discussions in this section have been under the presumption that all of the emotional processes have taken place under a logical conscious appraisal, neglecting the fact that emotions can also be triggered unconsciously through emotional memories. In an unconscious process, the cognitive resource requirement is minimum if any at all, meaning that the significant changes should only show in emotions (such as anger, tension and depression) but not in cognitive resource requirements. In the case of the unconscious emotional process, out of the three aspects of the environment (dominancy, subjective quality and appropriateness), only the dominance of an environmental factor would be important as it decides which factor(s) are responsible for triggering the emotional memory. The subjective quality and appropriateness of the factor(s), then, become somewhat irrelevant since no actual appraisal process occurred.

7.3.3 Context difference between on-site case study and laboratory study

Context difference and their effects were also observed between the laboratory environment (studies from chapters 5 and 6) and the in-situ locations (study from chapter 4). This difference was also observed in past studies. Sudarsono, Lam and Davies' (2016) study examined the same type of soundscape under both in-situ and laboratory environments through means of a survey (rating of semantic differential scales). Through factorial analysis, Sudarsono and colleagues discovered two of the components, namely dynamic/vibrancy and communication, were independent in the in-situ environment, accounting for a total of 24% of the variance. However, the two components were combined into single components and the variance accounted for was reduced to 14%. In another study, Hermida, Lobo, Pavón, and Bento (2017) examined the difference in soundscapes of urban parks between in-situ and laboratory methodologies, the result of which showed that based on the PCM model, the in-situ test resulted in higher pleasantness and lower eventfulness compared to the laboratory test. A similar finding was also presented in this thesis study. Popular music performed on the streets had elicited more emotional responses than when it was replayed as recording in the laboratory due to eventfulness difference (see also discussion in section 7.1.1). Fountain sound only affected the fatigue mood state in the in-situ study (Chapter 4); instead, it increased the scores of multiple negative mood states (i.e. anger tension, confusion, fatigue) in laboratory studies (Chapters 5 and 6), hence a reduction in the pleasantness dimension. Based on the results from all three thesis studies, the laboratory context appeared to signify the emotional effect (more eventful) for certain sound types (i.e. traffic and fountain sounds) due to the laboratory containing much fewer ambient factors (contexts). However, this trend did not apply to all sound types, as shown by street music, where the presentation of sounds can have a stronger effect than the contextual difference.

In summary, the difference between the in-situ contexts and laboratory contexts here did have a significant influence on emotional responses, and this difference was manifest in differences in the ‘eventfulness’ and ‘pleasantness’ dimensions from the PCM perspective, and in turn, the difference in emotional responses. Results obtained from laboratory tests may reveal the underlying nature of different types of sound on emotional responses, but should be always tested if applied to any in-situ environments.

7.4 What does statistical significance represent

In the three thesis studies, all changes in emotional outcomes were considered as changes in the intensity of each mood or emotion categories. In the context of soundscape study, this intensity was represented by how congruence or incongruence the environment was to one’s goal. While this assumption in intensity change is not wrong, it does not explain the underlying cause of such changes in intensity. The significant change in statistical results regarding each mood or emotional category does not necessarily represent the change of intensity per se, rather what they represent is a change in the underlining factors that caused the intensity change in the mood or emotion categories. An understanding of the underlining factors that caused the intensity of emotional changes is arguably more transferable to other disciplines (such as soundscape). It also provides more flexibility in terms of its application in building and urban design than simple causal to outcome type results does.

The mood or emotional categories that were examined in the three thesis studies were from the six mood states categories included in the POMS, namely anger, tension, depression, confusion, fatigue and vigour. Based on the discussion throughout the three studies, the six categories could be grouped into three types of emotion-related groups: individual emotions; precursor emotions; and indicators of cognitive resource spending/requirement.

7.4.1 The individual emotions

The first type of emotional category is the individual emotions. This category is the one that people usually think of when using the term emotions. An individual emotion refers to a distinct appraisal pattern and core relation theme (Lazarus 1991, p. 39) that could differentiate it from all other types of emotions. In the thesis studies, this included anger and tension.

The unique core relational theme of anger is that there are others intentionally assaulting one's ego identity. The intensity of the anger is dependent on how strong the felt intentions are (or how much aggression has felt by the perceiver). This 'intention' of others is not necessarily their actual intention; this intention is rather a prediction of the perceiver and how he/she thinks the intentions of the others are related to their felt aggression. In the thesis studies, this felt aggression was represented by the quantitative data. A significant change in anger scores indicated a significant change in the quantity of the felt aggression of the perceivers, such as from not feeling insulted (did not perceive any aggression) to feeling insulted (feeling strong aggression and assuming an unfair intention from the others). In all three thesis studies, the appraised factors were from whether the sounds or contexts, both of which were environmental factors and none of them are sentient being that has conscious and cannot have intensions. It appeared that anger cannot be produced. However, more often than not, people do complain about their living environment being unpleasant and feel angry about it. In such cases, the environment is not to blame but rather the people or organisation managing or building such environment is to blame. Lazarus (1991, pp. 223-224) agreed that it was possible to blame the ‘system’ when no actual person or people were involved in the situation or when the situation encountered was too ambiguous or complex to interpret. This was also the case in the thesis studies. For the case study, the unsatisfaction of the urban public space could be blamed on the neglect in the management of local government. For the laboratory study, since the laboratory was prepared by the experiment conductor, the negative experience could be seen as unfair treatment from the experiment conductor.

The mood state category that is tension in POMS, is interchangeable with the anxiety emotion (see also the discussion in Chapter 3.6.2). However, the anxiety emotion is somewhat different compared to most other individual emotions. Anxiety (or tension) had only two appraisal components in its appraisal pattern, namely goal relevance and goal incongruence, and these two components are always included in all emotions. In a way, the distinctiveness of this emotion is that it only included these two appraisal components. On the one hand, any emotions that included these two appraisal components are not necessary anxiety (tension). On the other hand, it also means that all negative emotions are all sharing the similar nature of anxiety (tension), i.e. psychological stress or emotional distress (Lazarus 1991, p. 239). The intensity of the anxiety emotion is dictated by the goal commitment of a person (Lazarus 1991, p. 99). The goal of participants in the three thesis studies was to relax and the intensity of emotional distress felt by the participants were directly related to how committed the participants were to achieving a state of relaxation. The variables detected by the statistical significance in tension are the goal commitments of the participants and the level of the incongruence of the environmental factors in relation to achieving relaxation. The goal commitment and the level of incongruence (or congruence) are two sides of the same coin; where one changes, the other will follow. Hence, a high rating in tension indicated a strong incongruence and high commitment to achieving a goal. The low rating in tension indicated that the reverse was true.

7.4.2 The precursor emotion

Some moods and emotions may be formed before individual emotions. Most of them are not emotions per se but moods, as they lack a distinct emotional pattern. These moods or emotions are always associated with and followed by multiple individual emotions. This type of mood or emotion is referred in the following discussion as a precursor emotion. The range of individual emotions that follow a precursor emotion is often fixed as they share similarities with the precursor emotions. However, which individual emotion would be formed in the end depends on the situation encountered and how the situation was interpreted by the person who encountered it. In POMS, the precursor emotions are depression and tension.

Depression as a precursor emotion can lead to sadness, anxiety, anger and guilt. Depression, as discussed in Chapter 3, indicates a helpless situation that is yet to be accepted by the person. Examples of depression elicited situations in the study of inherently unpleasant environmental factors such as traffic sound which could not be changed by the participants and yet he/she still believed that there was hope that it might change for the better (such as traffic sound level being reduced). In Klinger's (1975) study, he argued that short term depression is a coping process stemming from the withdrawal of a failed commitment. This process indicates psychobiological resources have been spent to no avail. Also, Mirowsky and Ross (1990) argued in their study that depression was more likely to occur in people who preferred to have control over their surrounding regardless of whether the situation was good or bad. In other words, they were more likely to lose control over situations because not everything can be controlled. Based on the arguments from both literature, the depression emotion in the current study indicated that the appraisal of the environment had to be incongruence, and that the participants had to spend effort (mental or physical) to change the environment to suit their goal (i.e. relaxation). However, such effort was unfruitful, resulting in them feeling irreversible loss and hopelessness. In a broad sense, the statistical change indicated the intensity of the hopelessness felt in an environmental encounter. However, if looking into the source of such hopelessness, the statistically significant change in the depression score indicated the amount of effort put into controlling the environment changed significantly; hence it also indicated the likelihood that the participants preferred to have control over the related environment.

Tension is also a precursor emotion. However, tension is a special case in precursor emotions. As discussed in the last section, tension is also an individual emotion with a distinct appraisal pattern (see also Section 7.4.1). The uniqueness of tension as a precursor emotion is also embodied by tension being an indicator of emotional distress and a part of all negative emotions, thus drastically enlarging the range of individual emotion that follows tension compared to other precursor emotions.

7.4.3 The indicator of cognitive resource spending/requirement

In POMS, three mood state categories are highly associated with the cognitive resource spending in an appraisal process: fatigue; vigour; and confusion. The three categories explains a state but not emotions. The states in discussion are the change of balance between cognitive resource requirements to appraise an environment and the cognitive resource possessed by a person (indicated by changes in vigour and fatigue scores), or the potential of a significant amount of cognitive resource being spent (indicated by the changing of confusion scores).

Confusion as a result of an attempt to appraise environmental factors indicates a situation where the factors are not appropriate to its environments. The inappropriateness is different from the appraisal component – incongruence. The incongruence which is usually found in negative emotions indicates an environmental factor is an incongruence to one's goal. The inappropriateness, on the other hand, is not an appraisal component and is not a subjective evaluation of an environmental encounter, but rather explains a situation where a person cannot make sense of the factor within the context of the environment in which they dwell. Hence, confusion is not an emotion, nor does it have a close association with any individual emotions. How confusion participates in the emotional process is through the two potential outcomes that follow it. The first outcome is that the confusing situation is dismissed due to its difficulty in interpretation. The second outcome is that one would commit significantly more cognitive resources to try to make sense of the environmental factor (compared to when the factor is in an appropriate environment) that caused the confusion. Thus, a statistically significant increase in confusion scores indicates an increase in the likelihood of more cognitive resources having been spent. However, the statistical significance cannot determine which one of the two outcomes is more dominant in a population group, it can only indicate the potential of change in the cognitive resource without guaranteeing such change. Therefore, confusion cannot be used as the sole indicator for a change of cognitive resource; confusion should be used alongside other indicators such as fatigue and vigour. The importance of confusion as an indicator lies in its ability to detect the inappropriateness between factors and its environments. This ability is rather important when trying to identify the uniqueness or potential flaws in an environment.

Fatigue and vigour both explain a state of imbalance between the cognitive resource required to appraise an environment and the among of cognitive resource possessed by a person. A difference in one is opposite from the other. A fatigue state indicates that the cognitive resources required is higher than the cognitive resources possessed by a person, and a vigour state indicates the opposite. A significant statistical change in any of the two-states indicates a shift in the cognitive resource imbalance. A significant increase indicates that the imbalance is intensified and a significant decrease indicates that the imbalance is lessened. Fatigue and vigour, although representing two states that appear on the opposite ends of the same balance system, cannot replace each other in the role of indicator for cognitive resource spent. This is due to people responding to the same environmental encounter differently in different states; a change of one does not mean the other will also be affected. The results of this study showed that people's responses in the two states was independent. In the third study, the fatigue score of traffic sound was significantly reduced when combined with either the monk chanting context or alpine meadow context. This result indicated a reduction in the cognitive resource requirement to appraise the environments with the contexts. However, there was no significant change in the vigour score, which indicated the cognitive resource required to appraise the environment was not affected by the inclusion of contexts. This similar difference in results was also shown in the fountain sound and context combination (see also Table 6.4 for the comparison).

Importantly, the cognitive resource spent to appraise an environment is independent of the emotional reaction that resulted from such appraisal (see also the discussion in Section 7.3). The value of the indicators of cognitive resource requirement is that they provide information regarding the dominancy of factors in an environment. The more the resources required to appraise a factor, the more likely the factor will attract attention in the environment and thus become more dominant in the environment.

7.5 Applications in urban and architectural design

To apply the results of this thesis in urban and environmental design, one needs to understand the underlying mechanics of the emotional process. Two key aspects in the appraisal process must be considered in relation to the design if the emotional experience is to be taken into consideration. The goals of users as a crucial drive to form emotion need to be considered first. In the design of a space, a user's goal is mostly dependent on the function of the spaces. The function of an environment is usually pre-determined in the design, meaning that the goal of users in the space can be predicted. For example, in an office space the goal of the user is mainly related to work and meetings, and when types of work can be confirmed that will take place, the goal can be even more specific. The more dedicated the functions are the easier is to predict the goals of the users. The second concept is the environment. The word 'environment' here refers to the environment that will be constructed according to the design. In emotional reaction, there has to be a human-environmental relationship, and emotion essentially is the product that is produced when a person is appraising the environment in which they dwell in relation to his/her own goals. As discussed previously, in design, the goal of a person and the person in question can be predicted by the function of a space and its dedicated users, and the environment in the human-environment is determined by the design itself. As the design modifies the space so too will the emotional experience in the space change. Hence, if the way in which people with a certain goal respond to certain types of environmental factors can be confirmed, the emotional experience of a design can be anticipated by its designers. With this understanding of the relationship between emotional process and spatial design, the designing of emotional experience became tangible. In short, the function of space determines the likely goals of its users, and the goal and the anticipated environment through design together could predict the emotional response of its users.

The following sections will discuss the potential application of the results for urban and building design. The discussion is based on each mood or emotional category, each sound type and environmental context. Each factor is discussed regarding how they assist design thinking and any potential implementation in the design process.

7.5.1 Application of emotions in design

When considering each emotion or mood that was studied, the goal of implementing them in design is always to enhance or to reduce their felt intensity to create or avoid a certain emotional experience.

Anger

Anger is generated when others are blamed for their intentional attack on one's ego-identity. To illustrate the consideration of anger in building design, an example of an art gallery is used here. An art gallery's function is to display and exhibit art pieces and the goals of the visitors are most likely to appreciate and study the art pieces. The aim for the art gallery design should be to avoid any interruption of the appreciation and study of these art pieces, and an inappropriate design may be considered unresentful to the art pieces (insult to personal value) and lead to anger. Design considerations include avoiding the strong visual elements that could distract visitors or inappropriate design elements. The design can more actively complement the goals of the users, such as providing a narrative guide through spatial design to guide the user through spaces such as in an art gallery, or to provide a transitional space between the different styles of art exhibitions to avoid contradictory emotions between the two. In the context of anger, designers should also be aware that the design would not only be reflected in the immediate experience of users but also have social and political influence. As discussed in Section 7.4.1, in an environment lacking any clear person to blame, anger can be directed to the organisation or systems that manage the environment (such as the management team or designer of a building).

Tension (Anxiety)

Tension (anxiety) is a good indicator of goal commitment and emotional distress. If the tension score (anxiety) is high other negative emotions are likely to follow. This means that when designing a space, it is often better to avoid the creation of tension or anxiety. The intensity of the tension increases with people's goal commitments, and space with a designated function should carefully avoid introducing design elements that could be interpreted as an interruption for the space to fulfil its function. In a functional space like a theatre, reverberation time of the hall, viewpoint to the stage from the seating positions, and visual aesthetic of the interior should all be designed to serve the goal of watching performances instead of against it. However, users' goals are more varied and difficult to predict in some multi-functional spaces or space with weak functionality, such as a city square and an urban park. This makes avoiding the emotional distress caused by environmental factors more difficult to achieve. A better idea would be to distract rather than directly counter the undesirable effect. Similar ideas have already been intensively studied in soundscape – sound masking (Jeon et al., 2008; Axelsson et al., 2014; Hao et al., 2016). The effectiveness of distraction can also be seen in this study, where the monk chanting context successfully distracted the attention from traffic sound, resulting in a significant reduction in tension together with other negative emotions such as anger and depressive emotions (see also Table 6.5).

Depression

Depressive emotions result from an appraisal of an environment usually based on the past experiences of an individual, society-wide ideology or collective experience alike. These experiences are associated with certain environmental factors and may be triggered when observed. The experiences based on common ideology and collective experience can be avoided or elicited through design. An example is the Jewish Museum in Berlin, designed to elicit collective memory through the design of the space. However, depressive emotions can be triggered through environmental factors associated with individual experiences that are almost impossible to control.

Confusion Fatigue and Vigour

Confusion, as discussed in Sections 3.4.3 and 7.4.3, is not an emotion, but rather indicates that the inappropriateness exists in an environment and may cause the observers to spend a significant amount of cognitive resource to apprise it. Hence its value lies with its ability to identify inappropriate environmental factors from a given environment. This is invaluable in the survey stage of the design process. Identified factors may be enhanced or reduced in their ability to attract attention through the design to achieve the goals of a project. For example, if the environment is designed to suit the function of relaxation, any factor that could confuse the users is undesirable. This is because it increases the potential of the users spending a large amount of cognitive resource, contradicting the ideas of relaxing and recovering.

Fatigue and vigour each represent an imbalanced state between the cognitive resource required to appraise an environment and the cognitive resources possessed by an individual. This makes both of them good indicators to identify changes in cognitive resource spending/requirements. They are also good indicators for the dominancy of an environmental factor in the environment (see also Section 7.4.3). Their application in the design process is similar to confusion, which makes them useful to identify environmental factors that attract more attention than others in the early stage of a design. However, all three indicators (confusion, fatigue and vigour) rely on a survey which may not be possible depending on the circumstances of a design project. Therefore, they all rely more heavily on established study results than other moods or emotional categories do.

The application of emotions and mood categories by themselves is limited in providing a theoretical foundation and broad strategical guidance in design decisions. Without a combination of established studies and laboratory results, it is difficult to decide whether or not an environmental factor is beneficial to the design of a space. The next section and the one that follows discuss the individual environmental factors examined in the studies in this thesis.

7.5.2 Application of sound types in design

Street music

Based on the results of the first and second studies, street music (fast tempo popular music) was concluded to have a low association with the negative mood and emotion categories of anger, tension, and depression. This conclusion alone proved that the inclusion of fast tempo popular music as part of the environmental design was less likely to elicit negative emotions, due to its low association with emotional distress (indicated by low association with tension). The comparative results between the first study with the second and third studies showed that music does have a positive effect in reducing negative mood and emotions (anger, tension and depression). However, this effect was most effective if the fast tempo popular music is performed live rather than being replayed through recording because live performance is more eventful than a recorded one (see the discussion in Section 7.1.1). The reduction effect of the recorded music (in the second and third studies) on negative emotions was very insignificant when combined with more eventful sounds such as traffic sound and high flow rate fountain sound. Hence, recorded music is not recommended to be used to reduce negative emotional experiences if the negative emotional response comes from a more eventful sound. Live performance music, on the other hand, is very effective in reducing negative emotional experiences and distracting attention from the sounds that caused the negative emotions.

The results from the third study showed that introducing different contexts to fast tempo popular music (recorded) did not significantly affect emotional outcomes, indicating that recorded music (fast tempo popular) does not appear to take dominance over other environmental factors. This agrees with the previous notion that the inclusion of this type of music in environmental design is unlikely to inducing negative emotional experience in the worst case. However, as noted in this thesis, only this particular type of music has been tested, the application of the same conclusions applied to other types of music needs further study. The goals of the perceiver also need to be reconsidered if the function of the designing space is not for relaxation. Participants in the three studies had the same aim at relaxation, which was crucial to how the fast tempo popular music was appraised. Particularly in the monk chanting context, from the perspective of the participants in the laboratory (or tourists visiting the temple), the music might seem appropriate to the context. However, if considered from the perspective of the monks, the recorded music was more likely to be intrusive or annoying as it was incongruent with the goal of the monks, namely to meditate and practise through chanting.

The last application benefit related to street music was that the fast tempo street music required a low cognitive resource to appraise, especially when compared to the eventful sounds such as traffic and fountains sounds. Its relatively low requirement in the cognitive resource was also shown to be true even when the music was performed lively (as in the first study, confusion and fatigue reduced with the presence of live music). Street music's low cognitive resource requirement for appraisal indicated that music was also a good option if a design aimed to have low mental constraints on its users.

Traffic sound

The second and the third studies concluded that traffic sound was likely to elicit emotional distress (tension) and annoyance (mild anger). The high association with anger and tension indicated that traffic sound was highly incongruent to the goal of relaxation. The high association with anger and tension only appeared in the indoor (laboratory) environment but not in the outdoor urban environment (city pedestrian). This indicated that in a more appropriate environmental context the less dominant position of traffic sound (less eventful), also reduced its effect on anger and tension (see also the discussion in Chapter 4). All results from the studies indicated that traffic sounds were likely to produce a harmful emotional experience, with the best scenario to have no emotional effect at all. This indicated that traffic sound should be prevented or reduced whenever possible.

For the application of controlling sound in urban and architectural design, this thesis has shown that the direct approach of building physical barriers to block traffic sound is not the only solution. The thesis showed that introducing eventful and irrelevant environmental factors is a good way to reduce the negative emotional effect caused by the appraisal of the traffic sound. In the third study, when the monk chanting or alpine meadow contexts were introduced to the traffic sound, both contexts showed a different degree of effectiveness in reducing the negative emotion scores. Both contexts were different from the original context of the traffic sound, in other words, they were inappropriate when combined with traffic sound. Out of the two contexts, monk chanting was the more eventful of the two, which also had a more significant effect in reducing negative emotion ratings between the two contexts (see also Table 6.5).

There was also the potential to cause confusion and increase cognitive resource requirements to appraise an environment when adding traffic sound to an acoustically complex environment containing other dominant (eventful) sounds. In the second study, the sound clip combining traffic sound, fountain sound and street music was shown to have significantly higher confusion and fatigue scores, indicating that people in a complex environment with multiple dominant or eventful sounds (in this case fountain sound and traffic sound) were more likely to exhaust their cognitive resources (or mental energy in layman's term). This result showed that in the application of spatial design when considering how to distract attention from traffic sounds through introducing other factors, eventful sound may not be the best option. The designer should instead consider non-acoustical solutions, such as introducing vibrant (eventful) visual elements to the environment as part of the environmental context, or mixed methods, such as introducing a physical barrier to reduce sound levels and to reduce the dominance of traffic sound while introducing other eventful sounds to produce a pleasant emotional experience. This way only singular sound remains as dominant sound in the environment.

Fountain sound

The fountain sound in the studies had low variant and high flow rates, which was proved to be unpleasant in past studies (Rådsten Ekman et al., 2015). It was found that the fountain sound's effect on emotion was similar to the traffic sound in this study. Both were similar in terms of a high association with anger and tension that were also likely to cause confusion and increase cognitive resource requirements to appraise an environment when the environment is complex acoustically. This similarity means that the same design strategy applicable to the traffic sound could also be applied to the low variant high flow-rate fountain sound (i.e. distract attention from the fountain sound by introducing other dominant environmental elements). However, a similar strategy is almost unecessary, different from the traffic sound, the water sound from the water features in most cases are controllable. Therefore, the application of water sound should focus on utilising the positive emotional effect from a high variation water sound (Rådsten-Ekman, Lundén & Nilsson, 2015), such as a water feature with slowly flowing water dropping from different heights or fountains that changes pressure.

7.6.3 Application of contexts in design

Contexts by themselves are a mixture of environmental factors. The contexts that were explored in the third study of this thesis were combined with visual (photo of the site) and sound environments (with multiple sound types and one dominant sound). The contexts were each treated as one factor when discussed in terms of their application in design, resulting in the discussion of the application leaning more towards a general strategical guidance of the design context as a whole than for any specific contexts.

Temple courtyard

The temple courtyard context consisted of a still scene of the courtyard (see also Figure 6.2 for the photo), bird songs (relative consistent and dominant within the context) and the occasional human voice and walking sounds. The temple courtyard did not influence emotional outcomes (i.e. anger, tension and depression) when combined with the three urban sounds (i.e. street music, traffic sound and fountain sound). The only effect observed was the reduction in confusion and the cognitive resources spent to appraise when the context was combined with the fountain sound (see also the results in Table 6.4). This indicated that the sound of fountains was appropriate in the temple context. These non-significant results mean that contexts with uneventful environmental factors were unsuitable to be used as a design strategy to alter the emotional experiences of existing environments. However, introducing such context may reduce the cognitive resource requirement to appraise an environment if the contexts and existing environmental factors are appropriate to each other.

Monk Chanting

The monk chanting contexts consisted of a still scene of a temple interior (see also Figure 6.2 for the photo), monks' chanting sound and occasional tourist sounds. The monk chanting was an eventful encounter by the sound alone, as it shared similarities to a live performance in terms of its ability to attract attention. Eventfulness was considered here as the most effective way (out of the three) to alter the emotional experience (see also the results in Table 6.4). The results indicated that the environmental context with any eventful activity could drastically alter the emotional experience of an environment through distraction, for example, in a space with undesirable environmental factors with negative influence on emotions, such as an urban square with traffic sound. The designer could also consider including landscape design such as a small area with semi-enclosed hedges to encourage activity such as street performance to take place.

Alpine meadow

The alpine meadow context used in the third study (Chapter 6) consisted of a still projection picture of grassy plains of mountain ranges (see also Figure 6.2 for the photo) and consistent insect sounds. The alpine meadow context was not very eventful and the environmental factors contained were all nature-related. It caused a reduction in the anger experienced in traffic (see also the results in Table 6.4). This was likely caused by the pleasantness of the natural environment. A numbers of studies have shown the same phenomenon indicating that natural sound was perceived as positive and had a good recovery effect (Benfield et al., 2014; Mackrill et al., 2014; Yang & Kang, 2005a, 2005b). Adding the insect sound in the alpine meadow provided a continuous sound with variations, and this was more consistent and eventful compared to the bird song in the temple courtyard. Hence, despite the dominance of traffic sound, the alpine meadow context still managed to attract some attention away from the context.

Summary

To summarise, the eventfulness of the environmental factors within a context dictated the effectiveness of its ability to alter the emotional experience. Whether the effect was positive (decreased negative emotion or increased positive emotion) or negative (increased negative emotion or decreased positive emotion) depended on the inherent nature of the environmental factors themselves. Additionally, if an environmental factor was appropriate to its contexts, the cognitive resource required to appraise such a factor would likely be reduced. In terms of application in design strategies, designers are encouraged to create a spatial environment to include eventful and positively appraised design elements if the site inherently contains undesirable factors likely to produce a negative emotional experience. The design should also maintain the space as integrated as possible to avoid mental fatigue and confusion to its users.

Chapter 8: Conclusion and future work

8.1 Conclusions and contributions

This thesis attempts to further the understanding of the effect of the soundscape on emotional responses, more specifically the influence of soundscape and its factors' effects on individual's mood, emotion or emotional categories. The thesis observed and examined a number of factors and their ability to influence moods, emotions or emotional categories within the context of soundscape research. These factors include: (a) sound types, specifically street music, fountain sound and traffic sound; (b) weather conditions, specifically temperature and daylight; (c) the environmental contexts composed of visual and audio stimuli, including a temple courtyard context, a monk chanting context and an alpine meadow context; and (d) a major demographic factor such as gender. The mood, emotion and emotional categories examined together with the soundscape factors are anger, tension, depression, confusion, fatigue and vigour. This thesis started with a case study observing and examining the factors in an in-situ urban environment. The focus of the case study was to observe how the inhabitants of an urban environment respond to its environmental factors emotionally in their natural state. The environmental factors that were found to be significant or could have a potentially significant effect on emotional responses in the case study (chapter 4) were then further examined through two subsequent laboratory studies (Chapters 5 and 6). The findings and conclusion of the studies are as follow.

8.1.1 The effect of the soundscape of urban public space on emotional responses

The initial in-situ case study confirms that different sound types and environmental contexts had significant and different effects on individual mood, emotions or emotional categories. Three dominant sounds – street music (popular music), fountain sound (high flow-rate) and traffic sound – was observed and examined in terms of their effect on emotional response.

Two out of the three dominant sounds showed different degrees of effect on the six individual mood, emotion and emotional categories.

Street music was shown to be the most effective sound types in influencing emotional outcomes, where anger, tension, depression, confusion and fatigue were all significantly reduced in the presence of street music. This significance was later proven to be due to the music being performed live rather than via a recorded replay. The high flow-rate fountain sound was less effective in terms of influencing emotional outcomes compared to the street music. The significant effect of fountain sound was shown via the increased fatigue rating. As fatigue is not an emotion but a state that is emotion-related, the reduction of fatigue indicates that the listeners of the fountain sound (low-variant high flow rate) is more likely to be exhausted cognitively. The traffic sound was the only dominant sound that did not show a significant effect on emotional responses. This insignificance was later found to be the result of appropriateness between traffic sound and urban contexts. If a factor (such as traffic sound) is appropriate with their contexts, the effect of the factors on the emotional response is significantly reduced.

The case study has shown that if no dramatic change in temperature and daylight occurs in a short period of time, the emotional response to the urban environment is not significantly affected. This indicates that emotionally, people are insensitive to the subtle changes in the weather condition, hence they are unable to appraise the change.

The visual contexts were found to have a significant influence on emotional response in the case study, specifically two visual factors: the ice-cream van was shown to reduce depression, tension, confusion and fatigue while increasing vigour, whereas the street vendor was shown to reduce tension, confusion and fatigue.

The overall result of the case study shows that the sound types and environmental context are the main factors in an acoustic environment that had a significant influence on emotional responses. This was examined in the controlled environment of the laboratory in the second and third studies, respectively.

8.1.2 The effect of sound types on emotional response in an urban context

The first laboratory study tried to answer this research question, which focused on examining the three dominant sound types (i.e. street music, traffic sound and fountain sound) and their effect on emotional response in a controlled environment. The context of the urban environment is simulated through the static image projection of urban photos and a similar reverberation time was recreated in the laboratory setting.

The laboratory study observed that the significant effect on emotional outcome in the presence of the street music was not the effect of street music but due to the absence of other sound types. In other words, street music showed no significant effect on emotional responses. This difference between the results of the laboratory and in-situ case studies indicates that a major difference exists between the two studies. This difference is the result of the way that street music was presented. The live performed music in the in-situ study showed more effectiveness than the recorded replay of the same music in the laboratory. The major difference between a live performance and recorded music is its dominancy in their respective environments. As live music is more likely to attract attention, so too will it likely become the focus of the appraisal process and hence, the more likely that its effect on emotional outcomes will be shown.

A similar difference between the in-situ study and the laboratory study was also observed for traffic sound and fountain sound. The traffic sound was found to be insignificant in influencing the emotional response in the in-situ study, showing a significant positive correlation with anger and tension. The fountain sound, which was found to have a positive correlation with the non-emotion fatigue in the in-situ study, showing a significant positive correlation with anger and tension. The difference between the two studies, then, is that of context. In the in-situ case study, both fountain sound and traffic sound are more appropriate to its environment than it was in the laboratory setting, despite the attempt to simulate the urban environment in the laboratory. It was concluded that if environmental factors such as sound and its context are appropriate to each other, the effect of the factors on emotional response are reduced due to its reduced eventfulness.

Overall, it was concluded that street music has a low association with anger and tension emotions whereas traffic sound and fountain sound have a high association with anger and tension emotions. The effectiveness of each sound type on emotional response is largely dependent on its eventfulness (or dominancy) in an environment. Further, the eventfulness can be affected by the environmental contexts and presentation of the sounds.

8.1.3 The effect of environmental contexts on emotional responses

For the examination of contexts, three non-urban contexts (the temple courtyard, monk chanting and the alpine meadow) were selected and combined with the three urban sounds (the street music, the traffic sound and the fountain sound). The results showed that the non-urban contexts had different effects on emotional responses towards the urban sounds.

The monk chanting context was the most impactful context in emotional response due to the eventfulness of the chanting sound and because the context is the most inappropriate when combined with the traffic and fountain sound. The monk chanting context reduced the anger, tension, depression, confusion and fatigue ratings in the appraisal of traffic sound and reduced the anger and depression rating in the appraisal of fountain sound. The next less impactful context was the alpine meadow context, due to its composition of less eventful natural environmental factors (continuous insect sound, wind sound and visual of an alpine meadow). The alpine meadow context only reduced the anger and fatigue rating in the appraisal of traffic sound and reduced the confusion rating in the appraisal of fountain sound. The only emotion affected by the alpine meadow was anger, where confusion and fatigue are both indicators of cognitive resource spending but not emotion. The contexts that were not impactful in the emotional response is the temple courtyard context. This context only consists of frequent but non-continuous bird song, occasional human sounds and a visual of the courtyard, none of which is eventful. The only effect of the temple courtyard was reducing the confusion and fatigue ratings in the appraisal of fountain sound, and as mentioned previously, neither of the two categories is an emotion. Additionally, the appraisal of street music was not affected by any of the contexts. This was because the music had a low association with the negative emotions of anger, tension and depression, and the context's reduction effect on these emotions was insignificant. Furthermore, due to the nature of the music, none of the contexts were inappropriate when combined with street music, which also significantly decreased the contextual effect on emotional response.

The overall conclusion is that the eventfulness of a context mostly dictates its effectiveness in affecting emotional response. When considering how it influences the appraisal of other environmental factors such as sound, the increase of appropriateness between the context and environmental factors would reduce the contexts' effect in influencing an emotional response.

8.1.4 Other findings

Gender

The gender difference was found to affect when someone appraised an acoustic environment. In general, the female gender was more resilient to negative emotions specifically anger, tension and depression. However, the results also suggest that this resilience has a threshold, as the effect of the factors on emotional responses move beyond such a threshold, females become significantly more susceptible to negative emotions than males.

Cognitive resource and eventfulness

The thesis found that the focus of attention of the perceivers determines whether a factor(s) is being appraised in an environment. Emotion is produced through the appraisal of an environment or environmental factors against the perceiver's goal. If the attention of a perceiver shifts from one factor to another, it is most likely the emotional response that follows the appraisal process that also changes. Whether or not attention is being focused on a factor is determined by the dominant position (or eventfulness) of such a factor in its environment. The more dominant position a factor has in an environment the more likely it becomes the focus of an appraisal process. This also means that the less dominant factors and the potential emotional reaction it produced are likely to be ignored.

8.2 Future works

8.2.1 Expanding the variety in research in emotional categories and soundscape factors

This thesis has attempted to integrate the appraisal theory of emotion into the field of soundscape studies. The results have shown potential in the implementation of appraisal theory and the possibility of interpreting emotional responses in soundscape through the theory. However, the validity of implementing the appraisal theory may require further exploration (such as cross examination with standardised soundscape research methods). The small number of soundscape factors and emotional categories used in the thesis has shown that appraisal theory is a reliable way to examine emotional categories. However, more emotional categories and soundscape factors should be examined for a more complete understanding of human-environment relationships. The human-environment relationship is the foundation of appraisal theory and emotional responses. It is rather difficult to fully explore each potential pair of human-environment relationships; as the goal of the individual changes so too does the related human-environment relationship. This thesis initiates a good start in exploring a systematic understanding of emotional responses in soundscapes. Based on this, the more emotional responses of other soundscape factors should be examined.

In terms of emotional categories, the emotional categories that were included in the thesis serve the function of a tool to examine and attempt to integrate appraisal theory into soundscape studies. Hence, the variety of the emotional categories included was not important to such an objective. However, more varieties of distinct emotions that could be the potential outcomes of appraising an acoustic environment should be explored in future studies. For example, the positive emotions that were absent in this study. The inclusion of more emotional categories also means the need for new questionnaires suitable to observe the respective emotional changes; therefore this also needs to be developed in future studies.

In future studies, the inclusion of emotional categories and soundscape factors should be selected in consideration with the function of the space being studied. The function of space determines the primary goals of its user and the goal of the individual would determine how an environmental encounter is being appraised. Hence, the function of space would also influence the potential emotional outcome that could be produced in such a space.

8.2.2 Soundscape and cognitive resource

The thesis used confusion, fatigue and vigour as indicators for the changing of cognitive resource requirements/spending during the emotion forming (the appraisal) process. Changes in cognitive resource requirement when appraising an environment has helped to identify the dominancy of the soundscape factors examined in the thesis. However, there remains uncertainty when it comes to when cognitive resource are being viewed as a psychophysiological function.

An individual's possession of cognitive resources cannot be infinite, as proved by the existence of the fatigued state. Subsequently, the following questions arise: how can one's cognitive resource recover, after spending cognitive resources to appraise an environment; under what condition(s) can an individual recover their cognitive resources? This thesis has assumed that the cognitive resource would recover automatically when a person is not appraising anything such as when sleeping. This assumption is logical on paper, however, is it truly possible for anyone to not appraise their environment at all during a conscious state? It is safe to assume that one's cognitive resource has a limit. But it is unclear how much this limit differs between individuals, how individual differences influence their cognitive resource repository and whether this repository fluctuates under different situations.

The thesis also discussed that three dimensions that could influence the requirement to appraise an environmental factor. They are the *eventfulness,* the *qualitative nature,* and the *appropriateness* to its environment. However, it is uncertain how much each dimension would dominate the cognitive resource required to appraise an environmental factor. Can one of the dimensions explain more percentage of the requirement more fully than the other two? More importantly, can the cognitive resource requirement be quantified and predicted through the three dimensions?

Overall, cognitive resource spending/requirement is crucial in the study of emotions and soundscapes, as to a large degree it dictates whether or not an environmental factor (such as sound) would be appraised by the perceiver. More future study would be required to fully understand how cognitive resources function as a system.

8.2.3 Distraction of soundscape factors in complex situations

This thesis discovered and discussed the change of emotional responses caused by the distraction effect from acoustic factors. The more dominant and eventful soundscape factors distracted attention away from less dominant factors. However, the acoustic environments examined in the thesis are relatively simple in terms of their composition of stimuli (with two to three sounds). Without further study, it is unclear how the distraction effect is going to function under more complex acoustic environments. It is more than likely that the attention would be split between multiple stimuli. It would be ideal for future studies to work towards developing a model that could quantify the attention that is shared among stimuli in a given environment and how the emotional response is going to be affected by each potential outcome of the distribution of attention.

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Appendix A:

Profile of Mood States questionnaire (First study, Chapter 4)

	Feeling	Not at all	←		→		Extremely
1	Friendly	1	2	3	4	5	6
2	Tense	1	2	3	4	5	6
3	Angry	1	2	3	4	5	6
4	Worn Out	1	2	3	4	5	6
5	Unhappy	1	2	3	4	5	6
6	Clear-headed	1	2	3	4	5	6
7	Lively	1	2	3	4	5	6
8	Confused	1	2	3	4	5	6
9	Sorry for Things done	1	2	3	4	5	6
10	shaky	1	2	3	4	5	6
11	Listless	1	2	3	4	5	6
12	peeved	1	2	3	4	5	6
13	Considerate	1	2	3	4	5	6
14	Sad	1	2	3	4	5	6
15	Activity	1	2	3	4	5	6
16	On edge	1	2	3	4	5	6
17	Grouchy	1	2	3	4	5	6
18	Blue	1	2	3	4	5	6
19	Activity	1	2	3	4	5	6
20	Panicky	1	2	3	4	5	6
21	Hopeless	1	2	3	4	5	6
22	Relaxed	1	2	3	4	5	6
23	Unworthy	1	2	3	4	5	6
24	Spiteful	1	2	3	4	5	6
25	Sympathetic	1	2	3	4	5	6
26	Uneasy	1	2	3	4	5	6
27	Restless	1	2	3	4	5	6
28	Unable to Concentrate	1	2	3	4	5	6
29	Fatigued	1	2	3	4	5	6
30	Helpful	1	2	3	4	5	6
31	Annoyed	1	2	3	4	5	6
32	Discouraged	1	2	3	4	5	6
33	Resentful	1	2	3	4	5	6

34	Nervous	1	2	3	4	5	6
35	Lonely	1	2	3	4	5	6
36	Miserable	1	2	3	4	5	6
37	Muddled	1	2	3	4	5	6
38	Cheerful	1	2	3	4	5	6
39	Bitter	1	2	3	4	5	6
40	Exhausted	1	2	3	4	5	6
41	Anxious	1	2	3	4	5	6
42	Ready to Fight	1	2	3	4	5	6
43	Good-Natured	1	2	3	4	5	6
44	Gloomy	1	2	3	4	5	6
45	Desperate	1	2	3	4	5	6
46	Sluggish	1	2	3	4	5	6
47	Rebellious	1	2	3	4	5	6
48	Helpless	1	2	3	4	5	6
49	Weary	1	2	3	4	5	6
50	Bewildered	1	2	3	4	5	6
51	Alert	1	2	3	4	5	6
52	Deceived	1	2	3	4	5	6
53	Furious	1	2	3	4	5	6
54	Efficient	1	2	3	4	5	6
55	Trusting	1	2	3	4	5	6
56	Full of pep	1	2	3	4	5	6
57	Bad-tempered	1	2	3	4	5	6
58	Worthless	1	2	3	4	5	6
59	Forgetful	1	2	3	4	5	6
60	Carefree	1	2	3	4	5	6
61	Terrified	1	2	3	4	5	6
62	Guilty	1	2	3	4	5	6
63	Vigorous	1	2	3	4	5	6
64	Uncertain about things	1	2	3	4	5	6
65	Bushed	1	2	3	4	5	6

Appendix B1:

Profile of Mood States (POMS) questionnaire with open questions. Used in both pilot test 1 and the main experiment of the second study (Chapter 5). This is the base used for translation into Chinese in the main experiment.

Gender				Age			
	Feeling	Not at all	↔				Extremely
1	Friendly	1	2	3	4	5	6
2	Tense	1	2	3	4	5	6
3	Angry	1	2	3	4	5	6
4	Worn Out	1	2	3	4	5	6
5	Unhappy	1	2	3	4	5	6
6	Clear-headed	1	2	3	4	5	6
7	Lively	1	2	3	4	5	6
8	Confused	1	2	3	4	5	6
9	Sorry for Things done	1	2	3	4	5	6
10	shaky	1	2	3	4	5	6
11	Listless	1	2	3	4	5	6
12	peeved	1	2	3	4	5	6
13	Considerate	1	2	3	4	5	6
14	Sad	1	2	3	4	5	6
15	Active	1	2	3	4	5	6
16	On edge	1	2	3	4	5	6
17	Grouchy	1	2	3	4	5	6
18	Blue	1	2	3	4	5	6
19	Active	1	2	3	4	5	6
20	Panicky	1	2	3	4	5	6
21	Hopeless	1	2	3	4	5	6
22	Relaxed	1	2	3	4	5	6
23	Unworthy	1	2	3	4	5	6
24	Spiteful	1	2	3	4	5	6
25	Sympathetic	1	2	3	4	5	6
26	Uneasy	1	2	3	4	5	6
27	Restless	1	2	3	4	5	6
28	Unable to Concentrate	1	2	3	4	5	6
29	Fatigued	1	2	3	4	5	6
30	Helpful	1	2	3	4	5	6
31	Annoyed	1	2	3	4	5	6
32	Discouraged	1	2	3	4	5	6

33	Resentful	1	2	3	4	5	6
34	Nervous	1	2	3	4	5	6
35	Lonely	1	2	3	4	5	6
36	Miserable	1	2	3	4	5	6
37	Muddled	1	2	3	4	5	6
38	Cheerful	1	2	3	4	5	6
39	Bitter	1	2	3	4	5	6
40	Exhausted	1	2	3	4	5	6
41	Anxious	1	2	3	4	5	6
42	Ready to Fight	1	2	3	4	5	6
43	Good-Natured	1	2	3	4	5	6
44	Gloomy	1	2	3	4	5	6
45	Desperate	1	2	3	4	5	6
46	Sluggish	1	2	3	4	5	6
47	Rebellious	1	2	3	4	5	6
48	Helpless	1	2	3	4	5	6
49	Weary	1	2	3	4	5	6
50	Bewildered	1	2	3	4	5	6
51	Alert	1	2	3	4	5	6
52	Deceived	1	2	3	4	5	6
53	Furious	1	2	3	4	5	6
54	Efficient	1	2	3	4	5	6
55	Trusting	1	2	3	4	5	6
56	Full of pep	1	2	3	4	5	6
57	Bad-tempered	1	2	3	4	5	6
58	Worthless	1	2	3	4	5	6
59	Forgetful	1	2	3	4	5	6
60	Carefree	1	2	3	4	5	6
61	Terrified	1	2	3	4	5	6
62	Guilty	1	2	3	4	5	6
63	Vigorous	1	2	3	4	5	6
64	Uncertain about things	1	2	3	4	5	6
65	Bushed	1	2	3	4	5	6

During the experiment session, is there anything attract your attention, even for a brief moment?
During the experiment session, is there anything on your mind? If so, could you summarise in a few words? (e.g. work related)

Date	

Appendix B2:

Profile of Mood States (POMS) questionnaire with open questions. Used in both pilot test 1 and the main experiment of the second study (Chapter 5), in Chinese as in the experiment.

性别				年龄			
	感觉，以及状态	完全没有	←		→		非常认同
1	友好的	0	1	2	3	4	5
2	紧绷的	0	1	2	3	4	5
3	生气的	0	1	2	3	4	5
4	疲惫不堪的；耗尽的	0	1	2	3	4	5
5	不高兴的	0	1	2	3	4	5
6	脑筋清楚的	0	1	2	3	4	5
7	活泼的	0	1	2	3	4	5
8	困惑的	0	1	2	3	4	5
9	为所做的事感到抱歉的	0	1	2	3	4	5
10	不可靠的	0	1	2	3	4	5
11	无精打采的	0	1	2	3	4	5
12	恼怒的	0	1	2	3	4	5
13	体贴的	0	1	2	3	4	5
14	难过的	0	1	2	3	4	5
15	活跃的	0	1	2	3	4	5
16	紧张的	0	1	2	3	4	5
17	不满的	0	1	2	3	4	5
18	忧郁的	0	1	2	3	4	5
19	活跃的	0	1	2	3	4	5
20	恐慌的	0	1	2	3	4	5
21	绝望的	0	1	2	3	4	5
22	放松的	0	1	2	3	4	5
23	无价值的	0	1	2	3	4	5
24	怀恨的	0	1	2	3	4	5
25	同情的	0	1	2	3	4	5
26	心神不安的	0	1	2	3	4	5
27	焦躁不安的	0	1	2	3	4	5
28	不能集中精神	0	1	2	3	4	5
29	疲乏的	0	1	2	3	4	5
30	对别人有帮助的	0	1	2	3	4	5
31	烦闷的	0	1	2	3	4	5
32	气馁的	0	1	2	3	4	5
33	充满忿恨的	0	1	2	3	4	5

34	紧张不安的	0	1	2	3	4	5
35	寂寞的	0	1	2	3	4	5
36	悲惨的	0	1	2	3	4	5
37	头脑昏昏然的	0	1	2	3	4	5
38	愉快的	0	1	2	3	4	5
39	痛苦的	0	1	2	3	4	5
40	精疲力尽的	0	1	2	3	4	5
41	焦虑的	0	1	2	3	4	5
42	剑拔弩张的	0	1	2	3	4	5
43	和蔼的	0	1	2	3	4	5
44	沮丧的	0	1	2	3	4	5
45	极度渴望的	0	1	2	3	4	5
46	行动迟缓的	0	1	2	3	4	5
47	反抗的	0	1	2	3	4	5
48	无助的	0	1	2	3	4	5
49	厌烦的	0	1	2	3	4	5
50	困惑的	0	1	2	3	4	5
51	警惕的	0	1	2	3	4	5
52	受欺骗的	0	1	2	3	4	5
53	狂怒的	0	1	2	3	4	5
54	有效率的	0	1	2	3	4	5
55	信任人的	0	1	2	3	4	5
56	劲头十足	0	1	2	3	4	5
57	易怒的	0	1	2	3	4	5
58	卑微的	0	1	2	3	4	5
59	健忘的	0	1	2	3	4	5
60	无忧无虑的	0	1	2	3	4	5
61	感到恐惧的	0	1	2	3	4	5
62	内疚的	0	1	2	3	4	5
63	精力充沛的	0	1	2	3	4	5
64	糊涂的	0	1	2	3	4	5
65	疲倦的	0	1	2	3	4	5

实验过程中，有什么东西或者事情吸引到你的注意力吗？	
如果有，你只是短暂注意到没有想太多，还是一直在观察/思考此事物	
实验过程中，你脑中有思考过什么事情吗？请用几个字总结（例如：工作相关）	
日期	

Appendix C1:

Profile of Mood States (POMS) questionnaire. Used in the third study (Chapter 6), translated into English.

Gender				Age			
	Feeling	Not at all					Extremely
1	Friendly	1	2	3	4	5	6
2	Tense	1	2	3	4	5	6
3	Angry	1	2	3	4	5	6
4	Worn Out	1	2	3	4	5	6
5	Unhappy	1	2	3	4	5	6
6	Clear-headed	1	2	3	4	5	6
7	Lively	1	2	3	4	5	6
8	Confused	1	2	3	4	5	6
9	Sorry for Things done	1	2	3	4	5	6
10	shaky	1	2	3	4	5	6
11	Listless	1	2	3	4	5	6
12	peeved	1	2	3	4	5	6
13	Considerate	1	2	3	4	5	6
14	Sad	1	2	3	4	5	6
15	Active	1	2	3	4	5	6
16	On edge	1	2	3	4	5	6
17	Grouchy	1	2	3	4	5	6
18	Blue	1	2	3	4	5	6
19	Active	1	2	3	4	5	6
20	Panicky	1	2	3	4	5	6
21	Hopeless	1	2	3	4	5	6
22	Relaxed	1	2	3	4	5	6
23	Unworthy	1	2	3	4	5	6
24	Spiteful	1	2	3	4	5	6
25	Sympathetic	1	2	3	4	5	6
26	Uneasy	1	2	3	4	5	6
27	Restless	1	2	3	4	5	6
28	Unable to Concentrate	1	2	3	4	5	6
29	Fatigued	1	2	3	4	5	6
30	Helpful	1	2	3	4	5	6
31	Annoyed	1	2	3	4	5	6
32	Discouraged	1	2	3	4	5	6

33	Resentful	1	2	3	4	5	6
34	Nervous	1	2	3	4	5	6
35	Lonely	1	2	3	4	5	6
36	Miserable	1	2	3	4	5	6
37	Muddled	1	2	3	4	5	6
38	Cheerful	1	2	3	4	5	6
39	Bitter	1	2	3	4	5	6
40	Exhausted	1	2	3	4	5	6
41	Anxious	1	2	3	4	5	6
42	Ready to Fight	1	2	3	4	5	6
43	Good-Natured	1	2	3	4	5	6
44	Gloomy	1	2	3	4	5	6
45	Desperate	1	2	3	4	5	6
46	Sluggish	1	2	3	4	5	6
47	Rebellious	1	2	3	4	5	6
48	Helpless	1	2	3	4	5	6
49	Weary	1	2	3	4	5	6
50	Bewildered	1	2	3	4	5	6
51	Alert	1	2	3	4	5	6
52	Deceived	1	2	3	4	5	6
53	Furious	1	2	3	4	5	6
54	Efficient	1	2	3	4	5	6
55	Trusting	1	2	3	4	5	6
56	Full of pep	1	2	3	4	5	6
57	Bad-tempered	1	2	3	4	5	6
58	Worthless	1	2	3	4	5	6
59	Forgetful	1	2	3	4	5	6
60	Carefree	1	2	3	4	5	6
61	Terrified	1	2	3	4	5	6
62	Guilty	1	2	3	4	5	6
63	Vigorous	1	2	3	4	5	6
64	Uncertain about things	1	2	3	4	5	6
65	Bushed	1	2	3	4	5	6

Appendix C2:

Profile of Mood States (POMS) questionnaire. Used in the third study (Chapter 6), in Chinese.

性别				年龄			
	感觉，以及状态	完全没有					非常认同
1	友好的	0	1	2	3	4	5
2	紧绷的	0	1	2	3	4	5
3	生气的	0	1	2	3	4	5
4	疲惫不堪的；耗尽的	0	1	2	3	4	5
5	不高兴的	0	1	2	3	4	5
6	脑筋清楚的	0	1	2	3	4	5
7	活泼的	0	1	2	3	4	5
8	困惑的	0	1	2	3	4	5
9	为所做的事感到抱歉的	0	1	2	3	4	5
10	不可靠的	0	1	2	3	4	5
11	无精打采的	0	1	2	3	4	5
12	恼怒的	0	1	2	3	4	5
13	体贴的	0	1	2	3	4	5
14	难过的	0	1	2	3	4	5
15	活跃的	0	1	2	3	4	5
16	紧张的	0	1	2	3	4	5
17	不满的	0	1	2	3	4	5
18	忧郁的	0	1	2	3	4	5
19	活跃的	0	1	2	3	4	5
20	恐慌的	0	1	2	3	4	5
21	绝望的	0	1	2	3	4	5
22	放松的	0	1	2	3	4	5
23	无价值的	0	1	2	3	4	5
24	怀恨的	0	1	2	3	4	5
25	同情的	0	1	2	3	4	5
26	心神不安的	0	1	2	3	4	5
27	焦躁不安的	0	1	2	3	4	5
28	不能集中精神	0	1	2	3	4	5
29	疲乏的	0	1	2	3	4	5
30	对别人有帮助的	0	1	2	3	4	5
31	烦闷的	0	1	2	3	4	5
32	气馁的	0	1	2	3	4	5
33	充满忿恨的	0	1	2	3	4	5

34	紧张不安的	0	1	2	3	4	5
35	寂寞的	0	1	2	3	4	5
36	悲惨的	0	1	2	3	4	5
37	头脑昏昏然的	0	1	2	3	4	5
38	愉快的	0	1	2	3	4	5
39	痛苦的	0	1	2	3	4	5
40	精疲力尽的	0	1	2	3	4	5
41	焦虑的	0	1	2	3	4	5
42	剑拔弩张的	0	1	2	3	4	5
43	和蔼的	0	1	2	3	4	5
44	沮丧的	0	1	2	3	4	5
45	极度渴望的	0	1	2	3	4	5
46	行动迟缓的	0	1	2	3	4	5
47	反抗的	0	1	2	3	4	5
48	无助的	0	1	2	3	4	5
49	厌烦的	0	1	2	3	4	5
50	困惑的	0	1	2	3	4	5
51	警惕的	0	1	2	3	4	5
52	受欺骗的	0	1	2	3	4	5
53	狂怒的	0	1	2	3	4	5
54	有效率的	0	1	2	3	4	5
55	信任人的	0	1	2	3	4	5
56	劲头十足	0	1	2	3	4	5
57	易怒的	0	1	2	3	4	5
58	卑微的	0	1	2	3	4	5
59	健忘的	0	1	2	3	4	5
60	无忧无虑的	0	1	2	3	4	5
61	感到恐惧的	0	1	2	3	4	5
62	内疚的	0	1	2	3	4	5
63	精力充沛的	0	1	2	3	4	5
64	糊涂的	0	1	2	3	4	5
65	疲倦的	0	1	2	3	4	5

实验过程中，有什么东西或者事情吸引到你的注意力吗？	
如果有，你只是短暂注意到没有想太多，还是一直在观察/思考此事物	
实验过程中，你脑中有思考过什么事情吗？请用几个字总结（例如：工作相关）	
实验过程中，你在做什么？	
日期	