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Understanding and Improving the Perception of a Hospital Ward Soundscape

By

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University of Warwick

WMG

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Engineering

March 2013

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DECLARATION AND INCLUSION OF MATERIAL FROM A PRIOR THESIS

The author declares that the work contained in this thesis is his own work and has not been used previously.

The research was undertaken independently within the Experiential Engineering Research Group, WMG, University of Warwick. All preparation, conduct, analysis and interpretation of the work was carried out by the author. No other data sources were used.

This thesis has not been submitted for a degree at any other university.

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LIST OF KEY ABBREVIATIONS

ANOVA = Analysis of Variance

CT = Cardiothoracic ward

dB = Decibel

dB(A) = A-weighted Decibel Level

ICU = Intensive care unit

NS = Natural sound

Pa = Pascal

PCA = Principal Component Analysis

SD WB = Step down ward bay area

SPL = Sound Pressure Level

SSI = Sound source information

SSS = Steady state sound

WB =Ward bay area

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Abstract

The various aspects of hospital environments have been shown to affect individuals psychologically and physiologically. One aspect of this, sound, has been thoroughly documented through acoustic measurements along with the potential adverse effects high sound level has on patients and nurses. Yet within hospitals, the character of the sound – the soundscape or the auditory landscape – is often overlooked in favour of this focus on sound level. This project has led to an improved understanding of the character and perception of hospital sounds using a triangulation of methods, with the intention of contributing to knowledge on how to improving the soundscape.

Firstly, an interview study with patients and nurses within a cardiothoracic (CT) ward at a UK hospital was carried out to understand perceptions of, and thoughts towards, the soundscape. This led to the development of a conceptual model linking the relationships between various concepts and components of perception thereby mapping the perception of the soundscape and the feelings it evoked. A key aspect to perception – the notion of coping through habituating to sounds, became the foundation for subsequent work testing positive interventions. These complex feelings elicited by the soundscape were then reduced into a two-dimensional perceptual space, extracted from a listening evaluation using Principal Component Analysis. Labelled 'Relaxation' and 'Interest & Understanding', these axies can represent the emotional-cognitive response stimulated by the CT ward sounds.

Finally, potentially positive interventions were assessed using listening evaluations with participants rating additional natural and steady state sounds, along with a cognitive intervention of sound source information (SSI). It was found that the interventions resulted in a small (η^2=0.05) but significant effect (p=.001) on the 'Relaxation' response. Natural sounds were most effective, with a less conclusive but still significant effect present for steady state sounds and SSI. The 'Interest & Understanding' dimension was non-significantly affected. Exploring this further, a between groups in-situ study assessed the benefit of SSI. The first group received SSI, the second received none. It was found that SSI had a small to medium significant effect (r=0.26-0.31, p=<.05) on 'Interest & Understanding' but not 'Relaxation'.

The project successfully developed a new way of assessing the perception of hospital sounds in a perceptual space. Using this approach it was concluded that natural sounds (here, the sounds of birdsong and a stream) provide a consistent way to improve the soundscape. However, a new approach of using SSI was successfully tested and was supported by a theoretical underpinning of cognitive reappraisal. Importantly, this offers an easier way to manipulate perception through potentially a reappraisal of the soundscape. Therefore, it was also concluded from the new findings and new theory that SSI could be used to create a positive response from people within hospital ward environments.

CHAPTER 1

INTRODUCTION AND CONTEXT

1.0. BACKGROUND TO RESEARCH

1.1. Introduction

This chapter introduces the research area including that of soundscapes and hospital noise, with a description of the research question and aims of the project. A description of the structure of the thesis provides the close of the chapter.

1.2. A 'Soundscape'

Predominantly, the impact of environmental noise is measured using sound level, ignoring the influence of other factors on the subjective experience (Irwin et al., 2011). Yet a soundscape can be defined as the auditory version of a landscape (Schafer, 1976) for a given environment and explains a much broader view of sound. Expanding on this concept, Truax (1984, p, 32) explains that speech, music and the sonic environment (all the sound energy in a given context) can be linked on their common basis, sound. Speech is communication through sound and a soundscape is the same because it is a form of communication derived from the sounds of the environment (Truax, 1984, p, 43). Therefore sound is an information source.

This communication approach deals with the transfer of information rather than energy and consequently deals with the cognitive processes that underlie this, along with the *perception* of sound (Truax, 1984). Perception can be defined as the interpretation of sensory stimuli which results in, importantly, the mental product or result of perceiving something (Oxford English Dictionary, 2005).

This is distinct from acoustics as it does not separate sound in its physical components from the cognitive process (Truax 1984). However, often sound level recommendations are given for environments as they can be monitored in an attempt to control 'sound' or noise. Yet, the absence of negative sound (noise) does not necessarily create a positive environment (Truax, 1984). Therefore, use of positive sound to enhance environments may provide an opportunity to use sound in the design of spaces to potentially enhance the feeling of wellbeing of users.

Much effort has been made to understand urban soundscape and how the perception of sound can be used to improve the sound quality, and the subjective experience of such places (Cain et al., 2013; Davies et al., 2013; Schafer, 1976; Yang, 2007). This moves away from metric analysis of sound to a more holistic ergonomic approach by the integration of objective measures with subjective perception, thereby building a richer picture of the individuals' response to the space. For example, Cain et al., (2013) proposed that the emotional response to the soundscape shows how a person feels towards that environment, providing a deeper understanding of the meaning of sound in the urban context and possibly the influence on the wellbeing of individuals.

1.3. Hospitals and noise

Within the UK, the National Health Service (NHS) recognises the fact that the environment of a hospital impacts individuals; *"The environments in which we live and work have a profound influence on our physical and psychological well being whilst research has repeatedly confirmed that a supportive and welcoming environment can have positive effects on those who visit and these who work in hospitals (The King's Fund, 2011)"*. Based upon this, the environment of a hospital affects those within it. As a result the soundscape of these spaces may be an important environmental attribute.

In agreement with Irwin et al., (2011) who stated that sound level measurement is common place, World Health Organisation (WHO) set out guidelines to keep sound level to a minimum in hospital environments. However, since the 1960s sound levels have risen within healthcare environments (Busch-

Vishniac et al., 2005) with the critical effects of excessive sound levels suggested to include sleep disturbance, annoyance and communication interference (Berglund et al., 2000). Recent research has considered the sound level in reference to the WHO guidelines (Akansel and Kaymakci, 2008; Anand et al., 2009; Hagerman et al., 2005; Tijunelis et al., 2005). Generally, these focused on intensive and critical care units.

The result of the continual documentation of hospital sound levels is that often sound within hospital environments is considered negative, with little or no attention given to sounds that are potentially positive. Some research has begun to touch on the perception of sound in these spaces. For instance, Rice (2003) conducted a study to understand the effect of hospital sounds on patients, remarking that hearing becomes pronounced whilst in hospital. Xie & Kang (2010) state the acoustic environment of a critical care unit environment can be *"very noisy"*, *"awful"*, and sometimes just made people *"want to run out the room"*. Akansel & Kaymakci's (2008) showed that despite over 90% of respondents to their questionnaire stating the hospital environment was noisy; most reported that it made them feel safe too. Therefore, an opportunity exists using Truax's (1984) communication approach to address this in a new way and to consider methods that can improve the perception of sound within these spaces for users. Dawson (2005) remarks there is scope for research into the positive effect of sound in healthcare facilities.

The presented research was a systematic assessment of a 'soundscape' within a Cardiothoracic (CT) hospital ward to understand the perception of the soundscape, positive and negative aspects, and potential means of improvements for users of the space.

1.4. Aim of research

As briefly discussed, the motivation for the research comes from the need to explore the notion of positive sound and consider the character and the perception of sound in hospital spaces, rather than the absence of it. This was identified as a current gap in knowledge by the author with the subsequent research question under investigation set out as:

"What is the perception of a hospital ward soundscape and how can it be improved?"

This central question under investigation was motivated by a desire to understand and improve the perception of a hospital ward soundscape. To achieve this in a robust manner the following specific objectives were made:

i. To capture, analyse and represent the perception and feelings of patients and staff towards a hospital ward soundscape.

ii. To record and analyse the objective attributes of the same hospital ward soundscape for reference, contrast and comparison with current literature.

iii. To create a perceptual space to represent and measure the subjective response to the hospital ward soundscape.

iv. To identify, test and measure interventions that potentially make a more positive response to the hospital ward soundscape.

v. To produce recommendations suggesting how and what interventions can be used to create a more positive response from individuals exposed to a hospital ward soundscape.

1.5. Structure of the thesis

The main body of the thesis describes the systematic approach to the research which addresses each of the objectives. Chapter 2 reviews the literature on sound in hospital environments and the effect that it has on both patients and staff. This highlights the current gaps in understanding. Soundscape theory and methods are also described to contextualise how this gap may be filled with the associated methodological approaches being underpinning the research explained in chapter 3.

The empirical research was conducted stage by stage using an iterative approach. Each was required to meet the objectives and design the subsequent steps in a specific and thought through manner. Chapter 4 answers objectives 1 and 2 and builds a conceptual model of hospital ward soundscape perception from patients and nurses by discussing the design, execution and results of an in-situ interview study. This is then contextualised by capturing the objective attributes (acoustic and sound source) of the soundscape. At this point a conceptual model of hospital ward soundscape perception was formed which underpinned the subsequent work and provided triangulation between the qualitative and quantitative elements. Chapter 5 then discusses an experimental stage using listening evaluations to understand the soundscape in further detail. This established a perceptual space which could be used to measure the subjective response to the hospital ward soundscape. Using this perceptual space, potentially positive soundscape interventions were tested. These are discussed in chapter 6 with their development underpinned by the conceptual model of hospital ward soundscape perception. The empirical work culminated in a final pilot study conducted in-situ within the CT ward to test the impact of sound source information as a positive soundscape intervention on a patient demographic. Each chapter has a separate discussion of the findings with a more general discussion presented in chapter 7 where the merits and limitations of the work are assessed. Recommendation, future work, and conclusions provide the close of the thesis.

CHAPTER 2

LITERATURE REVIEW

2.0. Introduction

There are many aspects to the physical environment within hospital spaces. Some are tangible, for example the physical surroundings and some intangible such as sound. This chapter reviews current literature around the area and discusses the development of the research question and how this addresses the current gap in knowledge. This review focuses on defining sound and soundscapes and moves on to discuss the area sounds in hospitals environments with the review drawing parallels and distinctions between the two areas throughout.

The assessment of literature was carried out using a variety of databases such as Science Direct, Web of Knowledge and Google Scholar using various key words such as ‘sound in hospital’, ‘noise in hospitals’, ‘soundscape perception’ among others. Reference lists were also examined for related papers to gain a comprehensive collection of key and relevant research.

2.1. PART A: SOUND AND SOUNDSCAPES

2.1.1. Sound in the environment

Sound levels and the notion of noise is a feature of all environments, with the subjectivity of sound and its effects being explored by broad and varied research. First it is necessary to define sound and noise. Plack (2005) produced a book detailing the ‘Sense of Hearing’ and his simple concise definitions can be used here to answer this. Sound can be as defined pressure fluctuations in the air that stimulate the auditory systems (Plack, 2005). The main function of this system is to get information from the outside world into the brain where it can be used to plan future behaviour (Plack, 2005, p,62). After all, we often learn and interpret environmental sounds as either direct or indirect meaningful events (Keller & Stevens, 2004). In essence this is the process of sound perception. A sound source produces a sound (pressure fluctuations) at a discrete point in space rather than spread over a wide area (Plack, 2005, p33). Therefore, an environment that has a collection of sound sources which combine to produce a soundscape. Noise is one way a sound can be perceived, processed and interpreted. A broad definition of noise is any unwanted sound (Plack, 2005, p26). This will be returned to in section 2.2.

2.1.2. Soundscapes

There are a number of ways to assess sound within a given environment. Most commonly this is through acoustic (the scientific study of sound (Plack, 2005, p, 241) parameters, most commonly sound pressure level (SPL) or colloquially, the sound level. Perhaps a less common way is to consider the soundscape. A soundscape can be defined as the auditory version of the visual landscape (Schafer, 1976). Defining this concept further, Truax (1984) explains that speech, music and the sonic environment (all the sound energy in a given context) can be linked on their common basis; sound as a form of communication. This communication approach deals with the transfer of information rather than energy (Truax, 1984) and therefore deals with the cognitive processes that underlie it. As a result understanding a soundscape is an approach aiming to understand sound in terms of perception which can be used to formulate ideas to improve perception to a given soundscape. This is particularly useful as the focus of the auditory stream is dependent on acoustic properties, knowledge, familiarity, context, expectation and association (Payne, Davies & Adam, 2009). Therefore sole objective measures, for example, SPL, are not useful as they do not relate to any individual and subjective meaning, which the study of a soundscapes acknowledges. For instance, Thompson

(2002) states sound is a physical part of the environment and a way of perceiving that environment which the soundscape approach acknowledges.

This focus on a soundscape has led to much effort being made to understand the urban soundscape and how the perception of sound in towns and cities can be used to improve the subjective experience of these places in an effort to drive policy and building planning. Such studies include those of Cain et al., (2013), Davies et al., (2013), Schafer, (1976), Yang, (2007) to name but a few. These studies move away from acoustic analysis of sound to integration of objective measures with subjective perception, thereby building a richer picture of the individuals' response to the place. As will be discussed, this provides a deeper understanding of the meaning of sound in context and possibly the influence on the subjective wellbeing of individuals.

2.1.2. Current trends in environmental soundscape research

Importantly, it must be acknowledged that soundscape work has been conducted in environments other than just urban spaces. Smaller scale research has explored specific soundscapes such as Tardieu et al., (2008) exploring the soundscape of train stations. Predominantly however, soundscape research generally falls within two themes relevant to the presented research:

- Assessing the urban soundscape with regards to improved design.
- Assessing the perception, interpretation and cognitive processing of the soundscape.

The urban soundscape has produced much research in relation to cities and parks. Yang & Kang (2005) used an intensive questionnaire survey (9200 interviews) along with objective sound measurement (a one minute L_{eq} equivalent continuous sound level) with the aim to evaluate the acoustic comfort in 14 urban public spaces across

Europe. Using a subjective rating scale, participants were asked to evaluate the soundscape at the site of the interview and their home. Participants classed sounds as favourable, neither favourable nor annoying or annoying. The results showed that with a lower background sound level people felt quieter which, Yang & Kang (2005) state, is important in creating comfortable urban environments. Moreover, if the sound level was below 73dB(A) then subjective evaluation correlate reasonable well with average sound level. However, the authors then go on to suggest that acoustic comfort has no such relationship with sound level as it is more complex with arguably greater dependencies. Importantly, Yang & Kang (2005) state if a pleasant sound, for example music or water, is introduced to the environment it can considerably improve acoustic comfort even if the sound level is higher, thus producing a more spurious relationship with sound level than is expected. Explaining this Yang & Kang (2005) found there was a positive correlation between a loss in acoustic comfort and the sound of demolition. However, when demolition and fountain sounds were presented the acoustic comfort was rated higher due to the masking effect provided by the fountain. Concurring De Coensel et al., (2011) found the benefit of such sound in increasing pleasantness to sounds such as traffic. Furthermore, the biophilia hypothesis promotes the benefit of the association of nature has for most individuals, be it through visual or auditory stimuli (Grinde & Patil, 2009). Perhaps the most important points to take away from this comprehensive investigation are that the acoustic environment is one of the main factors influencing the overall comfort within an urban space (Yang & Kang, 2005). This approach may therefore be relevant to understand a hospital space.

Expanding on these findings, in the book ‘Urban Sound Environments’ Kang (2007) reports on a field survey of two squares in Beijing. Both of these were located alongside a busy road and exposed to traffic noise. However, one square contained the presence of user activities such as dancing, roller skating thus creating a different soundscape. Using questionnaires, each square was evaluated based on the acoustic comfort. Interestingly, people using the square for rest and activity were more satisfied with the soundscape than passers through. It is remarked that these people were engaging with the soundscape, something absent from the first square with no activity. Therefore, Kang (2007) puts forward that psychological adaptation created by the different activities present within the soundscape along with positive aspects and falls into two categories (Kang, 2007, p, 81):

- Human activities or active sound.
- Sounds from landscape elements or passive sounds.

The findings indicate that active sounds influence the perception of the environment more than passive sounds with regards as to what is perceived as a pleasant environment (Kang, 2007, p, 81). This implies that ‘ambient’ sounds can be negative and additional sounds positive. This goes someway to support the previous findings of the positive association of water in Yang & Kang (2005) along with the lack of correlation with sound level.

Jennings & Cain (2013) go further to comment the perception of a soundscape is dependent on demographic factors, activity, temporal variation, type of space and location. This framework considers the environmental context and takes into account the dimensions of activity, time, space, considering the relationship between sound engineering data, and the interplay of multiple sound sources in creating positive soundscapes (Jennings & Cain, 2013). The framework has yet to be validated but it provides a tool which shows the variety of characteristics involved in assessing a soundscape. Indeed, in an example of just one of these Yang & Kang

(2005) found that there was a significant difference in acoustic comfort ratings amongst different age groups.

In an example of the more subjective aspects of soundscape perception, Payne (2008) used Attentional Fatigue Restoration Theory (ART) to suggest that restorative soundscape experiences are important in achieving good quality of life. Indeed, the acoustic environment has potential for effect on human health and wellbeing (Axelsson, Nelsson & Berglund, 2010). ART describes restorative environments as enabling recovery from attentional fatigue and reflecting upon daily events and any problems (Kaplan, 1995). If individuals have attentional fatigued they are likely to make more errors, have reduced productivity and higher stress levels (Kaplan, 1995). The paper explored the specific role of perceived soundscape in providing psychologically restorative experience within urban parks. Using two urban parks, 395 participants were asked if to fill out a questionnaire about the soundscape and the perceived restoration. The most common sounds heard were natural sounds and happy people sounds but on average participants only perceived themselves as being slightly restored when leaving the park. Payne (2008) states it is unclear if participants expected to hear these sounds and therefore this influences their response. Interestingly, none of the contextual (visual) factors influenced their perception of restorative level, despite the fact that if conducting factor analysis on such data, visual and auditory feelings always appear on the same factor (Yang and Kang, 2005). Despite this discrepancy Payne (2008) shows there must be a psychological element to soundscape perception which is important to acknowledge. Indeed, when developing a scale to measure the restorative benefit of a soundscape Payne (2012) states that such tools help shift the focus from negative considerations of soundscapes to many of the positive psychological aspects that can be derived.

This is an example of the communication approach that can be used to assessing sound within an environment which Truax (1984) advocates.

A comparable study by Pilcher et al., (2009) looked at understanding how the soundscape at a national park influenced people’s experience of the environment. The study was conducted in two phases. First, the sounds visitors heard and the extent to which the sounds were judged as pleasing or annoying over three locations was recorded. Participants were asked to close their eyes and listen to the environment for three minutes, then complete a sound checklist from 34 items. After this they then rated each sound as pleasing or annoying using performance and importance analysis. Additionally, using sound recordings taken from the park, participants listened to four recordings which were manipulated to show the effect of larger crowds of people on their quality of experience. The results showed the presence of human generated sounds resulted in a decrease in the acceptability and pleasantness of the environment, similar to findings of Payne (2008). When considering the findings, context must been acknowledged. A national park is a natural setting. Therefore, the expectation is that there is an absence of human sound and as such, any perception of them will be received more negatively than when heard in the urban setting. This supports the activity centric framework of Jennings & Cain (2013) that perception is dependent on location, activity along with Kang’s (2007) notion that if the individual is engaged in the soundscape perception is different. Although Pilcher et al., (2009) acknowledges elements of response bias, this supports these context dependent relationships between sound and the wider environment, thus what is acceptable in one environment may not be in another.

2.1.3. Assessing the perception of a soundscape

As has been shown, soundscapes elicit a psychological response. Therefore, this needs to be understood and measured. Fortunately, this has been a popular area associated with soundscape work. Dubois et al., (2006) reviewed recent studies within the area specifically focusing on the cognitive categories people use to describe urban soundscapes based on verbal descriptions. Although there is no formal structure to the review, it documents a useful overview of many of the concepts and trends found within this area of research. Dubois et al., (2006) states the meaning of soundscapes is an attempt to bridge the gap between perceptual categories and sociological representation given to the sounds. Interpreting this, the aim is to link the perception of sound to the behaviour and effect of the individual. It should be remembered that the auditory system's primary function is to get information from the outside world into the brain where it can be used to plan future behaviour (Plack, 2005). The results of Dubois et al., (2006) showed that soundscape research is qualitative as the perception of the auditory environment is grounded within individuals' knowledge, experiences, values and physical context, rather than simply the physical properties which create the sound. However, physical properties of sound must be used to point towards the cues of these cognitive objects, that is sounds (Dubois et al., 2006). Therefore, acoustic attributes should be acknowledged in relation to the cognitive perception of sound.

These mental representations of urban soundscape cannot be observed directly, but this can be done by analysing how people talk about their sensory experiences (Guastavino, 2006). Identifying this, Guastavino (2006) carried out a semi structured questionnaire which was distributed across three French cities regarding the individuals' ideal soundscape and then their response to transportation noise. A total of 77 questionnaires were returned from university staff at the three cities. The results were analysed by clustering phrases and semantics, verified by two individuals with a 96% agreement. Summarising the main findings, sound of other people, nature, birds were the predominant categories for an ideal soundscape. Mechanical sounds were more negative. Importantly, similar trends were seen for the sounds that were actually perceived within the soundscape. Perhaps one of the most interesting aspects was that respondents thought a soundscape should have variety to be ideal (38% of occurrences in the questionnaires) and as such concur with Kang (2007) and Jennings & Cain (2013) with the soundscape needing a level of ‘engagement’.

Therefore, soundscapes are represented in memory on the basis of semantic features and their meaning, thus reflecting interactions between individuals and their environments (Guastavino, 2006). As such, the perception of sound and specific sounds that are positive are based on people’s experience and relationship to them, not solely the acoustic properties such as correlation between pleasantness and sound level. For example, Guastavino, (2006) concludes that in order to make acoustic parameters have relevance, the semantic meaning needs to be explored first.

A specific study looking at this was carried out earlier by Guastavino et al., (2005) assessing how people cognitively process soundscapes. They report the main findings of a series of studies assessing the perception and representation of the soundscape of people living in four French cities. The results of questionnaire surveys and two listening tests suggest that people categorise soundscapes as event sounds or background noise. Complex environmental sounds are processed as meaningful events providing information about interactions with environment

(Guastavino et al., 2005). This links to the communication the soundscape provides and such research explores.

Expanding on this notion of cognitive representation and processing in a more rigorous way, Irwin et al., (2009; 2011) looked at the neural activity of the brain associated with the perceptual and affective response when listening to an urban soundscape. Sixteen participants were fMRI (functional magnetic resonance imaging) scanned whilst listening to recordings of an urban soundscape. The soundscape clips were matched in sound level (71dB(A)) but differed in their pleasantness rating on a five point scale. The results showed that listening to the soundscape evoked responses from many different brain regions but importantly one of the main emotional centres of the brain - the amygdale. This suggests that sound level is not the only factor that determines the response to a soundscape (Irwin et al., 2011). This shows the cognitive response to the soundscape, supporting both Dubios et al., (2006) and Guastavino at al., (2005). Moreover, understanding the emotional response soundscapes elicit is important in creating a positive environment through sound (Irwin et al., 2009).

Continuing the physiological measurement of the response to a soundscape, Hume & Ahtamad (2011) assessed the physiological response of 80 participants to 18 urban soundscape clips. These clips ranged from horse hooves on roads to evening birdsong with traffic sounds. Heart rate (HR), respiration rate (RR) and electromyography (EMG) (muscle tone) were measured along with the subjective rating of pleasantness and arousal on a nine-point Likert scale. One of the most interesting results was the significant relationship between sound clip and HR. A significant inverse relationship was found whereby HR dropped when a sound clip was rated more unpleasant. RR and EMG produced non-significant relationships.

For example, a reduction in HR came from the sound of a fox screaming. Hume & Ahtamad state that this finding is comparable to other work from Bradley & Lang (2000) who found the largest reduction in HR was for a human screaming sound. This shows that soundscapes elicit a subject response that influences the physiology of the body. Therefore, improving the subjective response may have the ability to improve and maintain the physiological homeostasis of certain physiological components of the body. Application of a ‘positive’ soundscape may therefore be useful in a hospital setting.

Linking to this, Guastavino et al., (2005), Hall et al., (2011) and Irwin at al., (2011) support the notions put forward by Campbell (1983) that the reaction to an ambient stressor, defined as a background condition, for example noise, maybe emotional. This can be interpreted that if the emotional reaction to soundscape is negative, it will remain negative. Indeed Campbell (1983) states:

> “*The notion of negatively toned ambient stressor’s sustain negative emotional responses over extended periods of time*”

Further comments include that changes in contexts associated with the ambient stressor may occur, altering the stressor’s meaning (Campbell, 1983). Therefore, exploring positive and negative soundscape attributes is important in addition to the context in which they are experienced.

Addressing this, Cain et al., (2013) and Axelsson et al., (2010) explored the emotional and perceptual dimension of an urban soundscape. The result of the research shows how a person feels from listening to their environment, not simply how they describe it and produced perceptual spaces that describe and represent the perceived soundscape. The former extracted dimensions labelled ‘calmness’ and ‘vibrancy’ whilst the latter included pleasantness, eventfulness and familiarity accounting for 50, 18 and 6% of variance. Despite using differing experimental methods and *priori*, understanding these dimensions means that the response to an urban soundscape can be captured as these components represent a person’s psychological response. Indeed, further work by Hall et al., (2011) also defined the perceptual dimension of the urban soundscape suggesting that an urban soundscape elicits a perceptual response relating to pleasantness and arousal - comparable to both Cain et al., (2013) and Axelsson et al., (2010). These are examples of communication with the environment through sound as individuals interpret it. Such research shows that the experience of a soundscape creates an emotional response, which cannot be ignored in the design of a sound environment.

2.1.4. Sound and health

Sound can have detrimental effects on health with this being widely researched. Stansfeld & Matheson (2003) reviewed literature looking at the non-auditory effects of noise. Sleep disturbance is one problem area. They state that sleep disturbance occurs when there are 50 or more sound events above 50dB. The effects include tiredness, reduced helping behaviour and reduced processing of social situations. These views are supported by Muzet (2007) who conducted a literature review assessing environmental noise, sleep and health. The susceptibility of disturbance due to noise is dependent on many factors including age, sex, and importantly experience, supporting the individual factors which affect sound and its perception and reaction (Muzet, 2007). Environmental noise disturbance effects both slow wave and rapid eye movement sleep stages, associated with energy recovery, mental process and memory (Muzet, 2007). Therefore, within the hospital setting the need for patients to have restful sleep is important not only to their wellbeing.

Stansfeld & Matheson (2003) conclude that the effects of noise are classified under quality of life issues rather than illness, therefore implying sound within the healthcare environment affects the quality of life for both patients and staff. Although not directly related to healthcare, this indicates the potential impact of sound and how sound, although it may not be perceived as an important component of the environment, needs to be considered.

Environmental research has looked at the stress noise causes within people. Rylander (2003) theorized concepts that underpin this stating; *“noise creates altered homeostasis, physiologically and creates subjective annoyance”*. Noise affects the central nervous systems and the secretion of corticosteroids which affect the individual physiologically, such as increase blood pressure and possible depression of the immune system but also emotionally and behaviourally (Rylander, 2003). Indeed in support Hume, Van & Watson (2003) assessed the relationship between aircraft noise and sleep disturbance of people living around airports in an effort to guide government policy. Therefore, the soundscape of an environment is an important aspect in ensuring it is ‘positively’ perceived to help alleviate such issues.

2.1.5. Conclusions from Part A

This part of the review has focused on soundscape work and shows the benefits of understanding the perception to sound and the disconnect this often has with sound level. Additionally, there is evidence that the psychological effects of ‘negative’ sound influences physiological function. Therefore, understanding the soundscape of a hospital environment and the notion of ‘positive’ sound holds many potential benefits. This will now be discussed in the next section.

2.2. PART B: SOUND IN HOSPITAL ENVIRONMENTS

Some of the effects of sound on health have briefly been mentioned. However, it is important to consider sound in the hospital environment before any notions of what ‘positive’ sound might be can be formulated. This review focuses on gaining an overview of this and considers research discussing good hospital environments through to the effects of excessive sound level on patients and nurses within these spaces. This research is reviewed with parallels draw to the soundscape literature.

2.2.1. What is a good hospital environment?

Hospital spaces also have a soundscape. Taking a broader view first, the interaction between the healthcare place, the environment and people, is area of much research. This interaction was explored by Carolan, Andrews, & Hodnett (2006) who looked at defining the term ‘place’ in terms of nursing and health geography research. Relevant to the project, creating a healing place or environment was an interrelated component of both nursing and the surroundings. Andrews & Evans (2008) suggest that therapeutic relationships of nurse to patient, individual to place, include understanding patients’ perceptions and needs, requires research to be expanded beyond human geography and to focus on workplaces; that is the healthcare environment. Therefore, investigating the soundscape as a physical and social component of the environment encompasses this.

Considering the implications of hospital place there is a need to understand sound in the context of the whole environment rather than concentration on specific sources. Hospital environments should reduce anxiety, stress and make patients feel comfortable and safe (Douglas & Douglas, 2004). Moreover, hospitals should minimise anxiety and promote healing through the creation of an overall inviting calming and engaging environment (Douglas & Douglas, 2005).

Indeed, the Department of Health in the UK set up an Enhancing Healing Environment programme run by the King's Fund in 2000. This aimed to improve acute hospital environments which was rolled out across the UK focusing on mental health trusts. In 2011 the a report was published stating that the project had shown that from the most uninspiring environments it is possible to create comforting, welcoming spaces that are fit for purpose, value for money, and that can improve the quality of care and patient experience. Such government funded projects show that the physical surrounds of hospital spaces have a part to play in the wellbeing of individuals and as the report states, *"the environments in which we live and work have a profound influence on our physical and psychological wellbeing" (DoH, 2011).*

In the past there has been research into the effect of the built environment on patient in relation to these aspects. Research has linked poor design to anxiety, psychological and physiological discomfort. Ulrich (1992) remarks these negative effects can be counteracted by good design, promoting the need for physiologically supportive environments to help recovery and ease stress.

Using a quasi-experimental design, Ulrich (1984) showed that patients who viewed nature (trees) had shorter postoperative stays, took fewer pain relief drugs, and had more favourable comments about their condition in medical notes when matched with patients who viewed a brick wall. There was also a non-significant difference for patients with views of trees in developing minor complications. This research concurs with Wilson (1972) who also found similar results among a sample of postoperative patients when studying the effect of windows on intensive care delirium. The study concluded the presence of windows is highly desirable in the intensive care unit for the prevention of sensory deprivation, although only 100 participants were involved which limits the power of the inferences made.

This strand of research focusing on positive stimuli to promote healing has been researched by others too. In a questionnaire based study assessing patient and staff preferences to hospital (rooms with vs. without windows) Verderber & Reuman (1987) found if a room did not have a window, patients preferred photographs of nature. They concluded that the representation of nature (ocean, sea, sky) appears to help satisfy the human informational needs. This relates to the biophilia hypothesis (the attraction toward nature) which soundscape practitioner Guastavino (2006) advocates when commenting on the positive association with natural sounds. The study also showed respondents were not satisfied with views within the hospital, connected to the lack of control they have over the screens and curtains around them. Staff working in rooms without windows also reported lower levels of wellbeing. Windows and views helps develop a perceptual and cognitive link with the external environment as they provide a smoothing peaceful distraction (Verderber & Reuman, 1987) linking to the restoration soundscapes provide as advocated by Payne (2012) and suggested by Axelsson et al., (2010). Devlin & Arneill's (2003) review of the literature resulted in the notion that windows have a healing and stress reducing effect on patients and should be considered in hospital design. These studies show the need for the healthcare environment to be stimulating for patients and staff to help reduce stress and anxiety.

In order for environments to be 'stimulating' there needs to be the presence of a stimulus. Using findings from previous research within the area, Ulrich (1992) can be used to discuss such implications. Clearly citing Wilson (1972) he describes the need for ‘positive’ distraction as patients are exposed to:

> *“Sensory deprivation in health facilities (Ulrich, 1992)”*

Positive distractions are elements which produce positive feelings that hold attention and interest and therefore block worries (Ulrich, 1992). It is commented that the benefits of these interventions have been shown in short term groups, however, the greatest potential is for patients who are in hospital for a prolonged period of time in relieving their stress, anxiety, and physiological symptoms (Ulrich, 1992).

2.2.2. Sound in hospital environments

Sound is a part of the makeup of the hospital environment which can produce both positive and negative feelings for individuals. As the evidence from soundscape literature has presented, sounds can produce a positive emotional response and may be beneficial to wellbeing (Cain et al., 2011; Axelsson et al, 2010; Irwirn et al, 2011; Payne, 2012).

Looking at this, Altimier (2004) used existing research to argue that patients experience positive outcomes from environments which use natural light, peaceful sounds and pleasant views. The review indicates that as a result patients have a shorter hospital stay, less pain medication, and have fewer negative comments documented in patient notes. Staff also benefit from a less stressful working environment (Altimier, 2004).

Concurring, comments from a systematic review of the 30 papers that met the inclusion criteria of clinically controlled trials, Dijkstra et al., (2006) remarks healing environments encourage recovery and feelings of wellbeing. These spaces reduce stress and anxiety along with the adverse reactions associated to it. Indeed, they found that positive effects were seen for sunlight, windows, and a sense of nature potentially liking to the positive association of natural sounds. Devlin & Arneil (2003) agree, suggesting that windows can have a healing and stress reducing effect on patients and should be considered in hospital design.

All these factors, including sound mitigation, can be said to improve the hospital environment and contribute to patient wellbeing and recovery. Importantly, Dijkstra et al., (2006) remark, although the notion that the physical environment effecting well-being of patients is supported, the specific evidence regarding environmental stimuli is limited and the authors fail to comment on how it is achieved. Biley's (1996) literature review of hospitals as healing environments adds further support commenting that visually, pictures can brighten up the environment, and indoor plants promote a positive perception of the interior. Additionally, sounds of music and waterfalls in the background can have a positive perception and mask unwanted sounds. However, Biley (1996) states these notions fail to be empirically based.

2.2.3. Sound level in hospital environments

One important aspect of sound in hospital spaces is the notion of sound level. Before proceeding, sound level and more specifically one of its measurements decibel (dB), needs to be defined. Simply, dB is a unit of sound (Plack, 2005, p,243). More specifically it is a measure of sound intensity displayed in logarithmic units known as decibels (Plack, 2005, p, 14) and so refers to SPL. Often this are analysed using an A-weighted filter to mimic the response to the human ear[1]. As a result, the SPL (dB) of hospital spaces is carefully considered. The WHO set guidelines recommending sound levels within hospital environments. These acknowledge the impact excessive sound level has stating effects such as sleep disturbance,

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[1] A-weighting is a filter applied to dB value designed to represent hearing response at low sound level, mainly below 60dB (Pierre and Maguire, 2004).

annoyance, and communication interference, including interference with warning signals (Berglund et al., 2000):

> *“The* LA^{max} *of sound events during the night should not exceed 40dB indoors. For wardrooms in hospitals, the guideline values indoors are 30dB(*$LA^{eq)}$*, together with a 40dB* LA^{max} *during the night. During the day and evening the guideline value is 30 (dB* LA^{eq}*)…sound pressure level should not exceed 35 dB (*LA^{eq}*) in most rooms where patients are being observed”*[2]

Existing research has used these figures to demonstrate sound level in most hospitals exceeds these recommendations. In a literature review focusing on sound control in hospitals Joseph et al., (2007) reported that research has found peak hospital sound levels during the day often exceed 85 dB(A) to 90 dB(A). Sound emitted from some machines, such as alarms, can exceed 90 dB(A), equivalent to walking past a motorway (Joseph et al., 2007). Such sound levels are not a recent discovery. In 1968 Minckley (1968b) recorded median sound levels of 50-60 dB(A) in a hospital, yet during periods of heightened activity this increased to 60-70 dB(A) with peak levels of ≥80 dB(A). More recent research has shown that the problem has not been alleviated and is persistent (Figure 1).

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[2] LA^{max} represents the recommended maximum sound level. LA^{eq} represents the recommended average sound level in the space

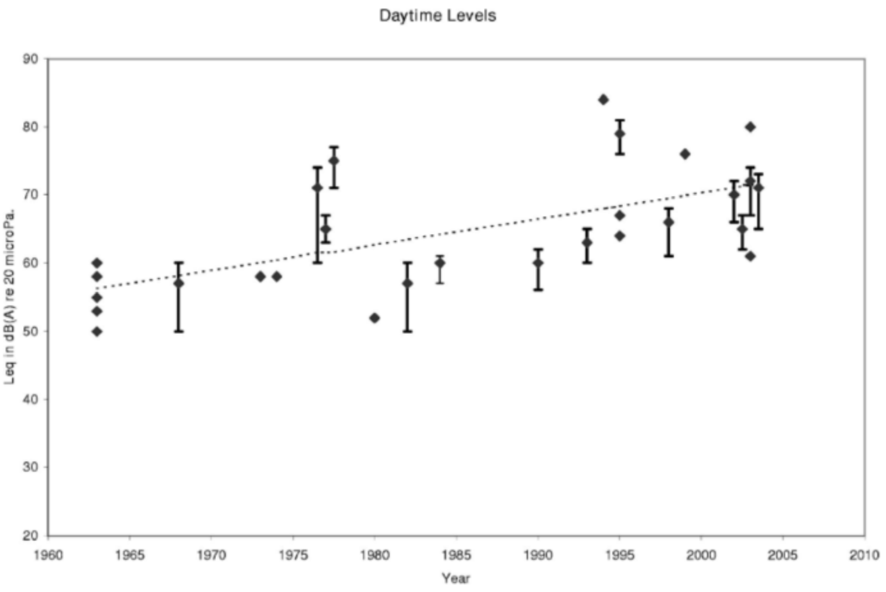


Figure 1. Showing the persistent rise in noise levels within the hospital environment taken from Busch-Vishniac et al., (2005).

Busch-Vishniac et al., (2005) cite this problem stating there is a clear trend for rising hospital sound levels since 1960 as most research shows that the average sound level is 20-40 dB(A) higher than that set out by the W.H.O. Using a consistent protocol measuring A-weighted sound pressure levels around a hospital, the study recorded mean sound levels to be 50-60dB(A) across five hospital units with little reduction in sound levels during the night-time. Unsurprisingly, this has implications for patients, visitors and staff within the hospital (Busch-Vishniac et al., 2005).

Care should be taken when interpreting such data however. Most commonly, the SPL is measured using the dB(A) value but this has potential limitations. Pierre & Maguire (2004) cite Berglund & Lindvall (1995) and Zwicker (1987) respectively stating correlation between dB(A) and loudness erodes as the sound level increases and that random noise is perceived louder than a single tone at the same SPL irrespective of weighting. Although considering the SPL of such environments is important, it is not the only detriment of what is perceived as potentially a good or bad sound. Moreover, such measurements do not perhaps consider the variety of sound within such hospital spaces. The interpretation and meaning behind them may offer more value as a means to improve hospital spaces.

2.2.4. Why are hospitals noisy?

Firstly, noise is a subjective notion as stated at the start of this review. However, much research adopts this term to describe sound in theses spaces. As such, hospitals tend to be noisy for two reasons; noise sources are numerous, often loud (paging systems, alarms, telephones) and the physical environment use hard ceiling, walls and floors thus increasing reverberations (Ulrich & Choudhary, 2004). For example, in a special care baby unit there are over 150 electrical devices, 90% of which have alarms (Scott, 1998). These create high peak sounds within the environment - a typical cardiovascular monitoring unit records a sound level >80dB (Siebig et al., 2009). This starts to build a picture as to the sources within these spaces and the complex soundscape that result.

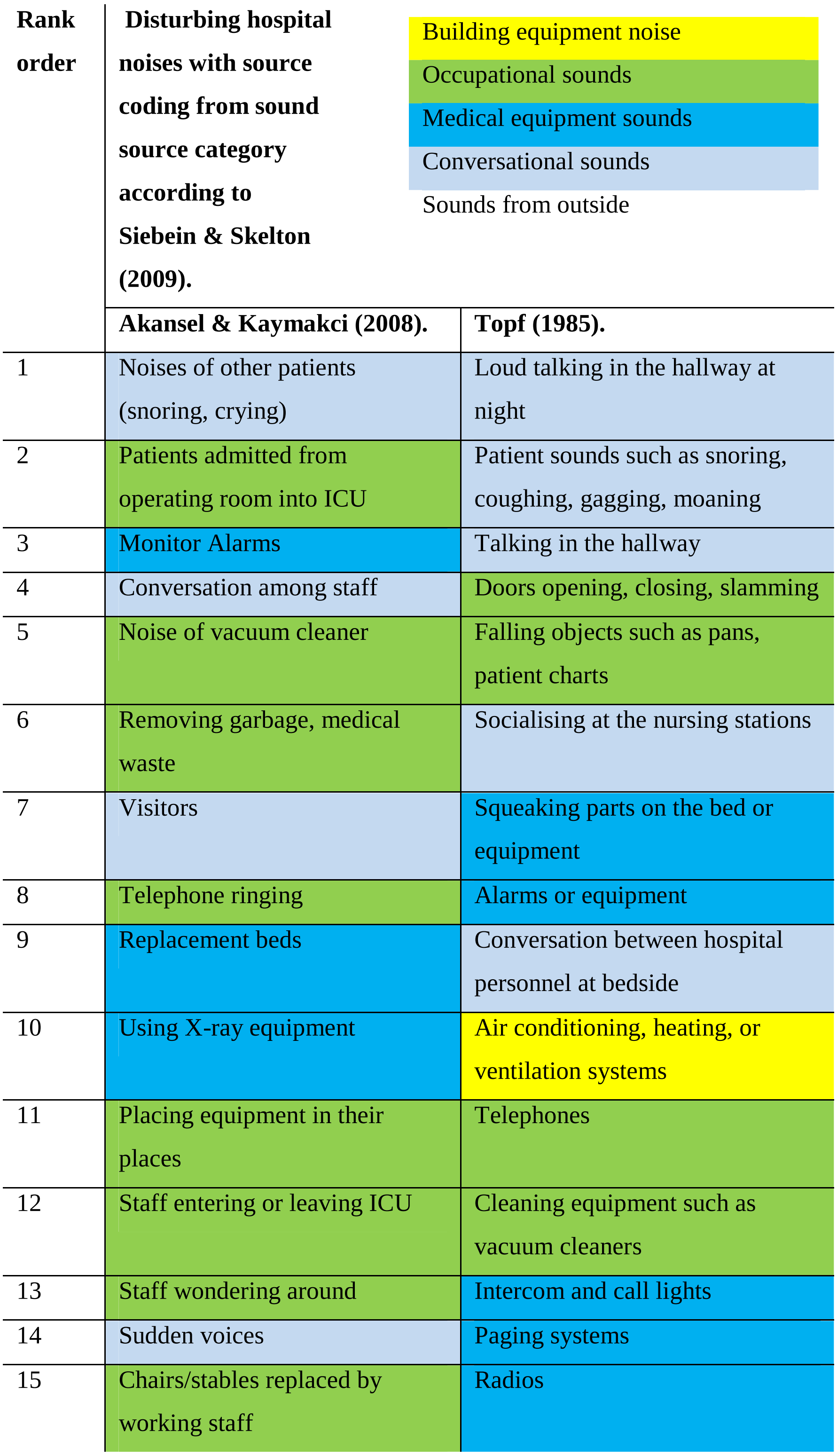
Akansel & Kaymakci (2008) studied the effect of noise on 35 intensive care unit (ICU) patients. Sound levels were recorded with a mean level of 64 dB(A) over the experimental period. A questionnaire assessed perspectives of disturbance caused by the noise within the unit. It was found that sounds from other patients, patients being admitted, monitor alarms, conversations and a vacuum cleaner were the most disturbing noises for patients. Statistical analysis showed a positive correlation in the relationship between noise levels and the number of patients within the space (Akansel & Kaymakci, 2008). The same effect was noted for staff numbers. Most importantly, patients who were located close to nurse’s station commented on the noise-creating activities performed by the staff. Conversations among staff were also disturbing to a majority of the patients independent of sound level (Akansel &

Kaymakci, 2008). Concurring Douglas & Douglas' (2005) large scale questionnaire survey patients reported being dissatisfied with the level of noise and disturbance, especially when located near to a nursing station. This begins to suggest, as soundscape research has, that the response to sound and what is deemed positive or negative is independent of SPL which guidelines fail to acknowledge.

Topf (1985) originally developed the hospital noise disturbance rating scale, as used by Akansel & Kaymakci (2008). From a pool of 24 hospital sounds defined from interviews and research, 150 male patients completed the scale. Results showed a correlation between objective noise levels and disturbance. However, they suggest that personal attributes predict disturbance to sound, rather than simply the highest sound level. The ecological validity is however limited, as the study was based in a military hospital and the perception of disturbance may be different from general public due to the experience and knowledge this groups has. The study of Akansel & Kaymakci (2008) provide a more usable set of evidence that validate these results by showing staff conversation was attributed to disturbance and to a certain degree SPL.

Of course, there is an array of different sound sources and characteristics within the hospital setting. Most research has taken a holistic approach, assessing the sound levels of the environment rather than focusing on specific sources (Busch-Vishniac et al., 2005; Akansel and Kaymakci, 2008; Minckley, 1968b). Staff conversation is one source which has been demonstrated to contribute to high mean SPL within hospitals. Akansel & Kaymakci (2008) reported common sounds to be telephones, monitor alarms, pumps, footsteps and conversation - ranked as one of the highest sound levels of 74dB(A)^{max}. In support of this, Siebein & Skelton (2009) specifically looked at sound sources and levels recorded within a neonatal intensive care unit. Audio recordings showed sound levels to be 54-65dB(A) and 38-59dB(A) on the two floors of the unit respectively. They documented 75 acoustic events under five categories which create the soundscape. These categories were building equipment noise, occupational sounds, medical equipment sounds, conversational sounds, and sounds from outside. The results showed that conversational noise accounts for the majority of sound within the unit as the competition with medical equipment means voices start to be raised (Siebein & Skelton, (2009). This concurs with other literature (Siebig et al., 2009) that medical equipment lead to high peak sounds (79-86dB(A)) and leads to a variation in the composition of the sound in terms of pitch (Siebein and Skelton, 2009).

From this literature it is possible to draw upon what is known regarding the hospital soundscape at this time. Both Akansel & Kaymakci (2008) and Topf (1985) documented the most disturbing hospital noises for patients which can be classified into sound sources according Siebein & Skelton (2009) (table 1). Usefully, this begins to show the makeup of the hospital soundscape in terms of types of sound, sources, and initial perceptions and impressions of them.



Rank order	Disturbing hospital noises with source coding from sound source category according to Siebein & Skelton (2009).	Building equipment noise Occupational sounds Medical equipment sounds Conversational sounds Sounds from outside
	Akansel & Kaymakci (2008).	**Topf (1985).**
1	Noises of other patients (snoring, crying)	Loud talking in the hallway at night
2	Patients admitted from operating room into ICU	Patient sounds such as snoring, coughing, gagging, moaning
3	Monitor Alarms	Talking in the hallway
4	Conversation among staff	Doors opening, closing, slamming
5	Noise of vacuum cleaner	Falling objects such as pans, patient charts
6	Removing garbage, medical waste	Socialising at the nursing stations
7	Visitors	Squeaking parts on the bed or equipment
8	Telephone ringing	Alarms or equipment
9	Replacement beds	Conversation between hospital personnel at bedside
10	Using X-ray equipment	Air conditioning, heating, or ventilation systems
11	Placing equipment in their places	Telephones
12	Staff entering or leaving ICU	Cleaning equipment such as vacuum cleaners
13	Staff wondering around	Intercom and call lights
14	Sudden voices	Paging systems
15	Chairs/stables replaced by working staff	Radios

Table 1. The rank order of the most disturbing hospital noises (Topf, 1985; Akansel & Kaymakci, 2008) and sound source classification (Siebein & Skelton, 2009).

Table 1 shows that occupational and sound generated by people, patients, and staff, are found to be the most disturbing. These account for 40% and 26.7% respectively of the overall disturbing noises sources for patients (Figure 2). These relate to the type of sound not simply the SPL.

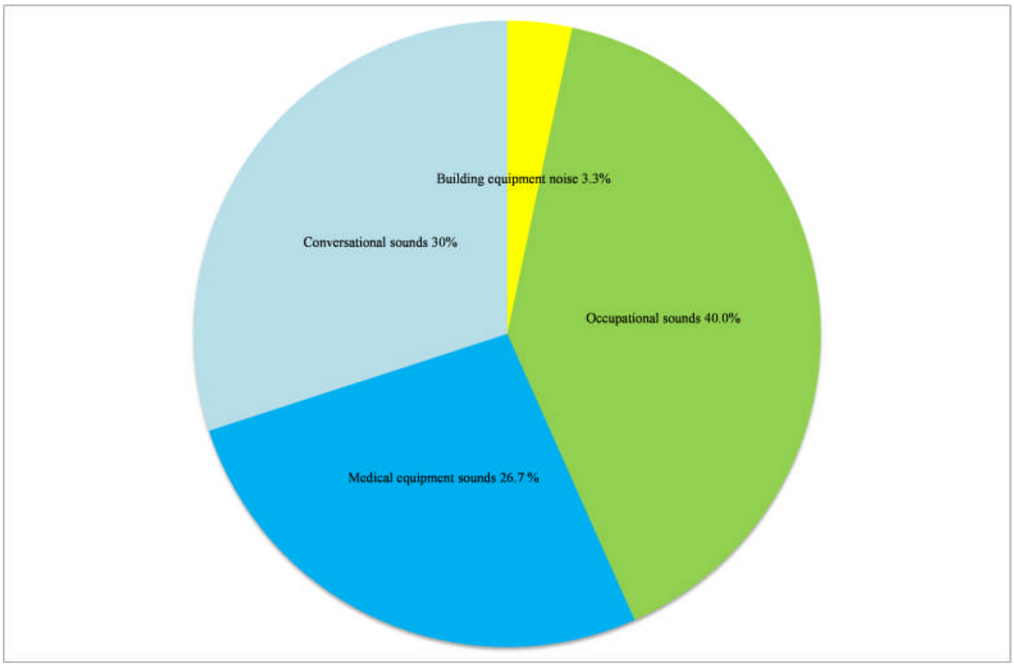


Figure 2. The percentage of patient’s disturbance each classification of sound contributed based on frequency of categories from table 1.

Bailey & Timmons (2005) studied sound levels in a seven bedded paediatric intensive care unit. Sound measurements were made at various times and points around the unit using a Tamma sound level meter A-weighted. The study showed that staff conversation was the major cause for excessive sound within the unit, which often exceeded guidelines. Bailey & Timmons (2005) also showed equipment/machines and information systems only account for 16.6% and 10% respectively concurring with figure 2. It can be suggested mechanical sounds generate less disturbance, perhaps because they are expected within the environment although this needs further investigation.

There is a problem with this potentially useful data however. Both authors fail to define the term ‘disturbing’. Without setting parameters to define this term there is some ambiguity within the results as the term disturbing is open to personal interpretation. Despite this the results show some consistent trends between them. Most pertinently, disturbing does not necessarily represent the loudest sound, thereby suggesting perception of the sound is important, supporting the subjective emotional response reported in soundscape work (Cain et al., 2013; Irwin et al., 2011; Hall et al., 2011). As there is sensory overload of abnormal stimuli which upon which noise sources bombard patients with sensory stimuli they are unaccustomed to (Akansel & Kaymakci, 2008), it can be suggested that hospital soundscape may elicit a strong emotional response from patients, something that has yet to be defined. Moreover, Akansel & Kaymakci (2008) found patients who had been in ICU two or more times were significantly less disturbed due to hospital sound (p<.05) suggesting that experience a level of habituation to such sounds effects the perception of the soundscape in these environments. This reiterates how sound level measurement fails to consider the psychological *experience* of sound.

2.2.5. The effect of sound in hospital environments

As has been shown in this section, sound in hospitals affect people. Usefully, both physical and psychological effects have been researched. Hagerman et al., (2005) evaluated the impact of room acoustics on patients with coronary heart disease. Using a quasi-experimental design, sound acoustics were altered using different ceiling tiles to reduced reverberation and thus SPL. The questionnaire based assessment recruited 94 patients and showed significant differences (p<.05) in the physiological state of patient between the two conditions reporting a reduced pulse rate with better room acoustics. Furthermore, rehospitalisation was higher for occupants within poorer acoustic rooms. Consequently, bad acoustics may have a detrimental effect of the recovery from acute illness (Hagerman et al., 2005).

This is not a new area of work. In an earlier study Fife & Rappaport (1976) compared cataract patients recovery time during heavy construction work outside the hospital to a group who had the same treatment when construction absent. The one-tailed test showed that hospital stay was significantly longer for the patients undergoing treatment during the construction work (p=<.05) suggesting the negative effect of higher SPL and the 'mechanical' sounds. Similarly, it has also been shown that patients in recovery rooms request more frequent pain medication when sound levels increase (Minckley, 1968a). Therefore, patients exposed to the quieter environment are likely to be more satisfied with the quality of care (Hagerman et al., 2005), arguably, a somewhat subjective effect.

Although sound level is detrimental it may be the type of sound, for example construction, which causes stress. This begins to show the need for research which considers the perceptual aspect of a hospital soundscape. Indeed, as Bailey & Timmons (2005) comment, staff and patients would suffer less psychological and physiological stress if noise levels were reduced, but noise, unwanted sound as Plack (2005) states, fails to be clearly defined in this context. Conversely but perhaps most importantly, Akansel & Kaymakci, (2008) showed that despite patients describing the assessed intensive care unit as noisy, 91.4% said that the units made them feel safe and the presence of technology and staff reinforced this. Such findings promote the psychological aspect of care with sound impacting on this by providing a communication between the individual and the environment. This indicates that the context of the soundscape is important. Along with the content or composition of the sounds these may be equally, if not more important than the physical sound level itself.

The adverse physiological and psychological effects of noise justify research looking at how the hospital soundscape can be made, at a subjective level, to be perceived more positive. This is highlighted by Yang et al., (2001) who showed in a comparative study of emergency staff nurses and ward nurses, saliva cortisol levels were higher in emergency ward nurses. This group also reported high rating of subjective expression of stress as a result of the environment of which sound was a component. However, Yang et al., (2001) state that it was hard to determine the relative contribution of environmental stress from the questionnaire. Despite the limitations, this indicates that sound has the potential for physiological effect which manifests itself in the subjective response of stress in the individual. This concurs with the broader environmental based research of Rylander (2003) by showing the physiological effect sound can cause. Therefore, the psychological and physiological reactions are interlinked. As such, improving the subjective psychological reaction to sound within the environment may be a way to help alleviate physiological stress.

2.2.6. Sound and sleep

Sleep disruption has been suggested as problem within hospital environments as a result of excessive sound levels. It has been shown that reduced sleep increases stress among patients whereas importantly, enhanced sleep accelerates recovery from illness (Dogan et al., 2005). Topf & Arand (1996) used recorded sounds of a hospital ward played back to a number of participants who were not ill in a laboratory study to assess participants quality of sleep. The results showed that the subjects who were played the audio recording experienced disruption to sleep, a longer time getting to sleep with less time sleeping as compared with the control group (no sound).

Interestingly, the group also used fewer positive adjectives to describe their sleep suggesting there is a psychological effect in terms of the subjective response to these sounds.

Douglas & Douglas (2005) support this. The comprehensive study included a sample size of 35 patients completing an autobiographic study, eight focus group and a sample of 785 completed postal questionnaires from in patients over a 12 months period. This showed that the main negative experiences resulted from a high level of noise at night and the disturbances that result from them. Backing this view up, Ulrich & Choudhary (2004) reviewed over 130 references and state that noise is a major cause of poor sleep in patients which has detrimental physiological and psychological effects, concluding that interventions to reduce noise have been found to improve sleep, alleviate stress among patients and improve patients’ physiological conditions.

Gardner et al., (2009) evaluated a schedule of quiet time with a sample of 299 patients over a 5 month period within an acute care setting. Using a non-randomized parallel group trial, the effect of sound level, recorded using an A-weighted sound meter in patient rooms, was measured against patients rest/sleep behaviour and wellbeing. Patients were matched on length of stay, living arrangements, and condition. Sleep status was recorded on three-point rating scale rating. The sound level difference between the conditions was 10.3dB(A) which corresponded to the experimental group experiencing half the sound level of control group. The experimental group showed a strong positive correlation between the sound level and the number of patients awake (r = 0.627, p=<.01) and asleep (r=-0.704, p=<.01) with 87% of patients feeling satisfied with the intervention. Despite limitations imposed by the lack of discharge and follow-up data preventing definitive conclusions being drawn, there was a relationship between rest, sleep, and potential wellbeing during the quiet time period (Gardner et al., 2009). Importantly, the overall strongly positive response from patients, visitors and staff suggests that scheduled quiet time would be a positively perceived intervention (Gardner et al., 2009). This concurs with Dogan et al., (2005) regarding the positive effect of reduced disturbance.

A consideration in interpreting these effects come from Akansel & Kaymakci (2008) who state patients who had previously worked in a noisy environment reported minimal or no disturbance owing to ICU sound. These socio-demographic variables demonstrate that people perception of sound varies with knowledge and experience. Thus, demographic, individual, and contextual factors are all variables that need consideration in interpreting the effect of sound which the activity centric framework of Jennings & Cain (2012) recognises.

2.2.7. Sound and stress

The WHO comments that sound level guidelines are important as patients have less ability to cope with stress (Berglund et al., 2000). Furthermore, staff have high levels of stress which noisy environments compound (Blomkvist et al., 2005). Topf & Dillon (1988) found that noise induced occupational stress was positively related to staff burnout with critical care units being most likely to cause distress among nursing staff. The most common effects of high sound levels on staff are increased perceived work pressure, stress and annoyance, increased fatigue and burnout as this leads to problems with communication (Joseph, 2007). Current research suggests that the hospital environment is characterized by a continuous barrage of stress-producing sounds (Mazer & Smith, 1998) and indeed excessively high sounds interfere with staff work (Bayo et al., 1995). As such the perception of sound within hospital settings needs investigating in a robust manner in order to understand what is positive and/or negative, and how individuals cope with this diverse soundscape.

Ryherd et al., (2008) assessed the reaction of 47 nursing staff to an ICU environment. The questionnaire results indicated that 91% said that noise negatively affected them and this was a contribution to stress symptoms such as irritation, fatigue tension headaches and difficulties concentrating. This was in an environment which recorded sound levels to be between 53dB(A) and 58dB(A) - comparatively low, implying the content or type of the sound affects stress levels rather than simply level. This reiterates Truax's (1984) notion that the soundscape is communication between the individual and the environment and therefore is open to interpretation. However, such thinking has not been applied within the healthcare environment. Moreover, the ICU environment was related to negative reactions by some of the nurses in the study and a large majority of the nurses also stated the risk for patients developing ICU syndrome due to the noise (Ryherd et al., 2008). Therefore, it can be said that it is the *type* and interpretation of a sound not necessarily the acoustic level that is important. Using examples from soundscape work again, natural sounds are perceived more positively than traffic (Gustavino, 2006) but the SPL may not necessarily be considerably different.

Considering this, Blomkvist et al., (2005) assessed the psychosocial environment among staff at the start and end of each shift across the day (morning, afternoon, night) for a one week period in a coronary critical care unit. This was followed by a four week experimental period where either sound absorbent ceiling tiles present or not. Reducing sound levels through these absorbent ceiling tiles resulted in hospital staff in the experimental condition perceiving reduced demands, less pressure and strain during the shift than the control group. Improvements in speech intelligibility were also reported. Such changes open up an increased capacity to care for the patients (Blomkvist et al., 2005) concurring with Hagerman et al., (2005) that the perceived quality of care improves with quieter room acoustic. Potentially, Blomkvist at al., (2005) cite caution however, as the findings imply that an approach for improving healthcare acoustics will be inadequate if it focuses narrowly on reducing sound pressure levels. Rather, a more effective approach will additionally emphasise environmental design interventions that shorten reverberation time of sound in these spaces. This supports the view that sound level is not the most important component of the hospital soundscape and potentially the character of the perceived sound within a space is. However, the authors' only focus on reducing reverberation as this has positive psychoacoustic benefits to the soundscape and other interventions need to be tested.

Limited research links the effect of patient care, staff performance and sound. Murthy et al., (1995) showed that during an operation, noise levels were recorded with an average sound level of 77 dBL_{eq} which had a detrimental effect in mental efficiency and short term memory of anaesthesia staff. Recently, and in concurrence with Blomkvist et al., (2005), Ray (2008) suggests the effect of noise is dependent on individual susceptibility but can include annoyance among staff and erode the quality of care. However, the direct effect of noise has yet to be determined in its contribution to medical errors (Busch-Vishniac et al., 2005) as there are many other factors to consider.

This reiterates that the perception and reaction of healthcare sounds needs more a formal investigation to assess the positive and negative components of the soundscape so the effects could be formally understood. Janssen (2008) touched on this by assessing how room acoustics affect patients perception of noise on an ICU ward and how a set of requirements should be formulated in order to develop supportive healthcare environments. Janssen (2008) concludes that more sound absorption within the room leads to a more positively perceived environment, although fails to describe how perception is measured or the magnitude of improvement.

2.2.8. Information

Sound is an information source for staff and patients - the communication with the environment - of which, arguably, monitors and alarms define key sounds associated with a hospital soundscape. Finley & Cohen (1991) assessed components of auditory alarm design specifically the perceived urgency of signal and its correlation with urgency with the clinical/medical situation. Warning signals from 10 hospital monitors were recorded. Alarms sounds were presented to participants for 12 seconds with inter stimulus interval. Seventy-two subjects rated 10 sounds on seven-point scale (not urgent–extremely urgent). The results showed no difference in professionals' assessments of urgency from the alarms. Anaesthetists were able to correctly identify the alarms only 33% time. Of the 10 stimuli only two sounds scored correct identification >50% of the time. Finely & Cohen (1991) conclude that the results show a poor correlation between the perceived and clinical/medical urgency of common operating room alarms and is therefore an ergonomic issues. The validity of these results may be questionable as the experiment was conducted in a quiet area of a conference centre, whilst a medical conference was taking place.

A more robust study by Cropp et al., (1994) was conducted in a listening room where 100 participants were asked to rate the sound out of 33 audible signals including 10 critical alarms. Only 50% of the critical alarms were correctly identified and 40% non-critical. There are usability issues (Cropp et al., 1994) associated with the sound of medical alarms, supporting Finley & Cohen (1991). Reiterating this, Drain (2003) reviewed the generic findings of current research in the area suggesting some alarms are either too loud, not loud enough, whilst others are difficult to hear in the environment. Furthermore, 34% of the time staff cannot identify the meaning of operating room alarms (Drain, 2003). In agreement, Momtahan et al., (1993) reported operating room staff can identify just 14 out of 23 different alarms of which most alarms are considered unpleasant. The ideal alarm should be audible or visual, not startle or annoy anyone, and have the correct spectral content (Drain, 2003).

This last point shows that although sound level in the environment is important, it is the content that is equally important in terms of what sounds create the soundscape. That is, the implication that alarms have to balance needs with perception. This is particularly important in hospital spaces as sound is a feedback mechanism for the care of patients and therefore needs consideration in relation to the whole environment. This is not investigated within this body of work.

2.3. Hospital sounds as a soundscape

So far the review has discussed the individual sound components of the hospital soundscape and their associated effect with a broader interpretation. From the literature reviewed limited work could be found focusing on sound in hospitals in terms of a soundscape, by understanding the perception and response in a holistic manner distinct from SPL. Using an ethnographic methodology with interviews, Rice (2003) investigated the sounds of patient life focusing on patients experiences of ward soundscapes at a public hospital in London, UK. Rice (2003) reports the reoccurring theme that hearing becomes pronounced whilst at hospital as the visual environment is dull and even restrictive, as other senses are not used and stimulated thus meaning these are made redundant. This concurs with Ulrich (1992) and

Wilson’s (1972) comments of “*sensory deprivation*” within hospital spaces. Indeed, the study takes a holistic approach to understanding the environment stating that the hospital environment is one which the sensory experience is ordered and therefore restrictive to patients. Posner et al., (1976) showed that if visual information is inadequate sound plays a more dominant role in people’s perception of an environments. Indeed, this effect was mentioned by (Rice, 2003) who reported that hospital patients’ perception of sound was higher as the visual stimulus generated by the environment was reduced:

> *“Lack of opportunity for in sight leads to the prospect of ‘in sound’”*

This lack of stimulus for other sensory modalities may therefore be a reason why the auditory environment becomes pronounced within the hospital setting and particularly affects patients. Truax (1984) cites Campbell (1983) stating habituation syndrome occurs in peoples’ response to noise, whereby at first they find it annoying but then it is too much trouble to do anything about it and therefore they become accustomed to it. Indeed, the subjective response sound manifests itself in a defeat reaction where people may become depressed which is particularly present in environments where individuals cannot escape from the exposure (Rylander, 2003). The hospital environment is one such environment where both staff and patients are subject to the same sound sources constantly. Along with the findings of Rice (2003) this shows the potential importance of ‘positive’ sound within these environments.

Such discussion implies the soundscape of a hospital should be always changing with periods of silence and other sounds to create a temporal element and stimulus for patients’. Mazer & Smith (1998) make this connection:

> *“It [hospital environment] should not be of any one type of sound all the time, change and flexibility is crucial in the sound environment”*.

A soundscape environment operates as a system where there is interplay and interdependencies that mean that the acoustic environment is balanced (Truax, 1984) making it a pleasant environment to be within. These environments are termed as a ‘hi-fi’ environment where there is a balance between sound sources and each can be heard clearly (Truax, 1984). This leads to the perception of a comfortable ‘positive’ environment whereas in an environment that is unbalanced the perception is noise resulting in information loss, encouraging a feeling of being cut off or separated (Truax, 1984). This supports the evidence of Rice (2003) who reported that hushed voices and hospital trolley squeaks became oppressive. Indeed, Truax (1984) suggests that these ‘lo-fi’ environments project a person’s attention inwards and as a result prevents interactions with others leaving individuals feeling alienated or isolated.

More recently, in an interview study Xie & Kang (2010) looked at the perception of 12 staff on the acoustic environment of a critical care unit and found the environment *“very noisy”, “awful”,* and sometimes made people “*want to run out the room*”. Medical equipment and conversation were the principal causes which the interviews described as ‘annoy’, ‘annoying’ and ‘loud’ concurring with Topf (1985) and Akansel & Kaymakci (2008) as one of the most disturbing sounds. They also highlight the problem of privacy in overhearing conversations within the unit linking to the notion that voices become oppressive (Rice, 2003). As a consequence it was suggested that sound distracts, alters concentration and increases tiredness amongst staff supporting Topf & Dillon (1998) that noise may play a role in staff burnout.

More broadly, Waye et al., (2010) used a questionnaire based study with 51 nursing staff to assess personnel response to intensive care units. Factor analysis revealed a three factor model relating to tiredness resulting from the sound environment including auditory fatigue (sound sensitivity, hearing fatigue, tinnitus), mental fatigue (tiredness, headaches, concentration difficulties, irritation), and tension (pain in the neck, stress, difficulties to motivate oneself). This relates to the findings of Ryherd et al., (2008) that alarms can lead to headaches and fatigue. Noise annoyance was significantly related to auditory fatigue (p=<.001) and mental fatigue (p=.05). This therefore is a negative effect of a poor soundscape and shows how designing a positive soundscape around individual's perception offers the best way to create an improvement to the sound of a hospital – after all, sound is a perceived sense.

As urban soundscape work has advocated, sound could enhance spaces such as these clinical environments. Research has begun to explore this. Thorgaard et al., (2005) performed a multicentre study in five post anaesthesia care units in Denmark. This questionnaire study investigated patient (n=325) and staff (n=91) opinion of specially design music environment through ceiling mounted speakers. Eighty three per cent of patients found the environment pleasant or very pleasing, 6% unpleasant and 11% had no opinion, with a strong correlation between the positive attitude towards the music and relaxation experiences. Staff had a positive attitude but this varied with location between the units. However, music and its effect on the working environment are determined by factors greater than the quality of music (Thorgaard et al., 2005). Using music as a positive factor for staff requires more effort than choosing the right genre of music (Thorgaard et al., 2005) supporting the notion that the perception of the healthcare soundscape and its cognitive representation needs to be known first. The data collection failed to capture the opinion and perception of the participants freely therefore somewhat biasing data, although the relatively large sample size suggests the results can hold a certain degree of ecological validity. Understanding the opinions and perspectives towards the environment first would yield a more successful result. This would place the psychological response to the interventions in a clearer context and enable and interventions to be evaluated against the thoughts of the individuals within the space before they were implemented.

2.4. PART C: ESTABLISHING THE RESEARCH QUESTION

Much research shows the problem of excessive sound levels within hospital environments and a detrimental effect on both patients and staff. However, the majority suggests that sound mitigation methods are the only way to improve sound quality within hospital environments. In the book ‘Acoustic Communication’, Truax (1984) states the dangers of just concentrating on sound level reduction:

> *“Loudness syndrome [the theory that noise at lower levels is acceptable] is ironic because the decibel level is a relative measure not an absolute one. All dB measurements are comparisons (a ratio) of a given level to some reference level…It is not a case where no negative noise creates a positive environment (Truax, 1984)”*

Soundscape research demonstrates that considering just the SPL provides an inadequate understanding of sound within an environment. Moreover, there are various approaches that have been developed with which to broaden our understanding of reaction to sound. Capturing perception and linking to the components of a soundscape is one way. Indeed a soundscape assessment is in depth and penetrates many areas in order to gain an accurate and valid interpretation of the environment. The majority of soundscape research has focused around the concept of planning and development of urban environments. The reviewed studies show consistent trends in terms of the perception, the categories used to describe sound and what sounds are generally preferred. However, it is important when assessing a new environment that the concepts and perceptions of the stakeholders are quantified ensuring the soundscape can be accurately measured.

This has highlighted the gaps present in the area of hospital sound research (Figure 3).

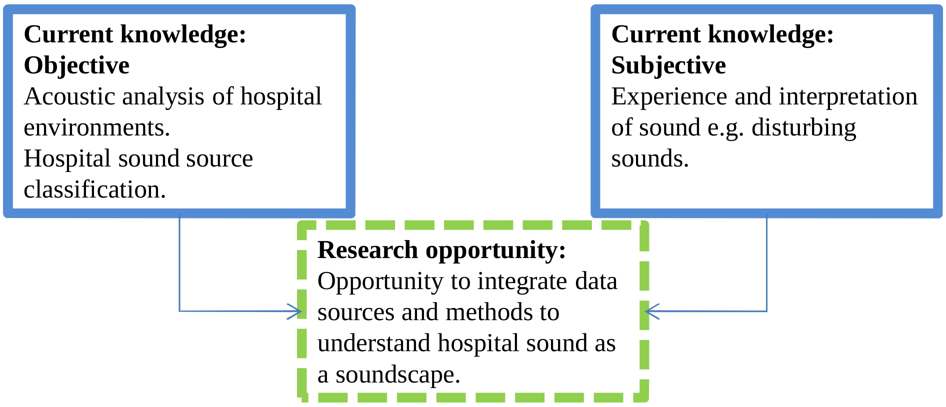


Figure 3. The current gap in knowledge regarding the hospital soundscape based on the findings of this literature review.

The WHO guidelines are used in much research and it was shown there is a persistent rise in SPL over time within these facilities. This crosses countries and has been proven to have a detrimental effect on physical and psychological wellbeing. Human sounds are generally perceived negative in the hospital spaces, labelled disturbing, but few if any of this research moves beyond these statements to suggests what might be positive. No research has used the systematic approach of measuring the perception to the soundscape from patients and healthcare professionals to formulate and tests positive soundscape interventions The small amount of soundscape research in the hospital environment (Rice, 2003; Xie & Kang, 2010) does not fill current gaps in knowledge as it does not provide a conclusive assessment, investigation and measurement of the perception to a hospital ward soundscape using a robust triangulation of qualitative and quantitative methods. However, there is an opportunity to do so in the ‘design’ of a positive intervention to improve perception.

The soundscape concept offers a vehicle to understand sound in hospital environments at a subjective level, considering the perception and interaction of sound in context and exploring it as a positive component of the environment. This moves away from the negative association of sound and noise, to the assessment of the emotional response, proven that soundscapes elicit (Irwin et al., 2011; Hall et al., 2011; Cain et al., 2013). Adapting these approaches by developing perceptual spaces (Campbell, 1983; Axelsson et al., 2010; Cain et al., 2013) means an understanding of potentially positive hospital soundscapes interventions can be both understood and measured. Firm support of this approach comes from Dawson (2005) in suggesting that the unacceptable noise hospital patients and staff are exposed to require examination of the sources, with scope for research into the positive effect of sound. Therefore current research fails to consider:

i. The perception of the soundscape within a hospital environment underpinned by a consistent methodology.
ii. What might be positive sounds within the environment and the reasons for this.
iii. Establish the perceptual or emotional dimensions of the hospital soundscape to use as a basis to test and measure the effectiveness of soundscape interventions.

Therefore, exploring patient and staff perception of a hospital soundscape may highlight ways to improve the soundscape beyond sound mitigation in a more feasible manner. Indeed, as has been mentioned, Busch-Vishniac et al., (2005) suggests that even though patients found the hospital environment noisy many found it safe suggesting the content of sound creates a different emotional response to the one sound level measurement would suggest. Indeed, as the healthcare experience is perceived as a visual, auditory, and temporal experience (Mazer & Smith,1998) sound must be considered as a whole in the environment which a soundscape approach does.

In a study looking at the role of hospital aesthetics on health and wellbeing Caspari et al., (2006) conclude that there is a need to explore the degree to which patients and staff are comfortable, how they evaluate hospital environments and their thoughts on the influences that effect their health, wellbeing and recovery. Despite some limitations in the paper this justifies exploring the hospital soundscape by investigating how sound can positively enhance these environment along with measurement of the subjective benefit primarily from patients but also staff. As Cain et al., (2013) suggests, using a soundscape approach allows an evaluation of environmental sound and moves away from acoustic engineering for reducing sound levels.

Therefore, based upon the literature and the interpretation of it described through the review, the guiding research question of the project under investigation was set as:

What is the perception of a hospital ward soundscape and how can it be improved?

The following specific objectives were set to achieve this:

i. To capture, analyse and represent the perception and feelings of patients and staff towards a hospital ward soundscape.

ii. To record and analyse the objective attributes of the same hospital ward soundscape for reference, contrast, and comparison with current literature.

iii. To create a perceptual space to represent and measure the subjective response to the hospital ward soundscape.

iv. To identify, test, and measure interventions that potentially make a more positive response to the hospital ward soundscape.

v. To produce recommendations suggesting how and what interventions can be used to create a more positive response from individuals exposed to a hospital ward soundscape.

The research question aimed to fill the current gap in research. Overall, this considered the hospital soundscape in one systematic, sequential body of work considering the perception and emotional response to these sounds. This moved to evaluate positive attributes that may exist and ways in which positive feeling could be formulated.

CHAPTER 3

METHODOLOGY

3.0. Introduction

This chapter introduces the approach taken to address the research question. Due to the iterative nature of soundscape assessment, no single method was used rather, a combination. The development of the methodology and the rationale behind it is discussed along with how the methods were chosen to deliver the research objectives. The sample demographic is discussed in light of the considerations needed when conducting research within a hospital setting. The specific methods used to design each stage and studies are described in more detail within their relevant chapter.

3.1. Research underpinning and approach

The central question under investigation was to understand and improve the perception of a hospital ward soundscape, as highlighted in chapter 2. Due to the stance put forward by this inquiry, the research can be classified under the broad subject area of ergonomics. Wilson (2000) defines this as understanding human behaviour in purposeful interacting systems (for example, environments) and the application of that understanding in the context of the real setting, for example a hospital. This highlights the interaction of people and environments and provides a multi-disciplinary theoretical understanding of these interactions and its application (Wilson, 2000) thereby creating a comprehensive assessment and conclusion to problems involving people.

In light of this definition, soundscape research improves a given space for individuals by considering the effect of sound on them, in a sense, designing the ‘soundscape’ for the users. This is consistent with ergonomics theory and practice and therefore underpins the research. Indeed, when discussing the approach of ergonomics Sanders & McCormick (1992, p, 5) explanation shows how the project and its objectives fulfil these notions:

> *"The approach of human factors is the systematic application of relevant information about human capabilities, limitations, characteristics, behaviour, and motivation to the design of things and procedures people use and the environments in which they use them. This involved the scientific investigation to discover relevant information about humans and their responses to things, environments (et cetera)."*

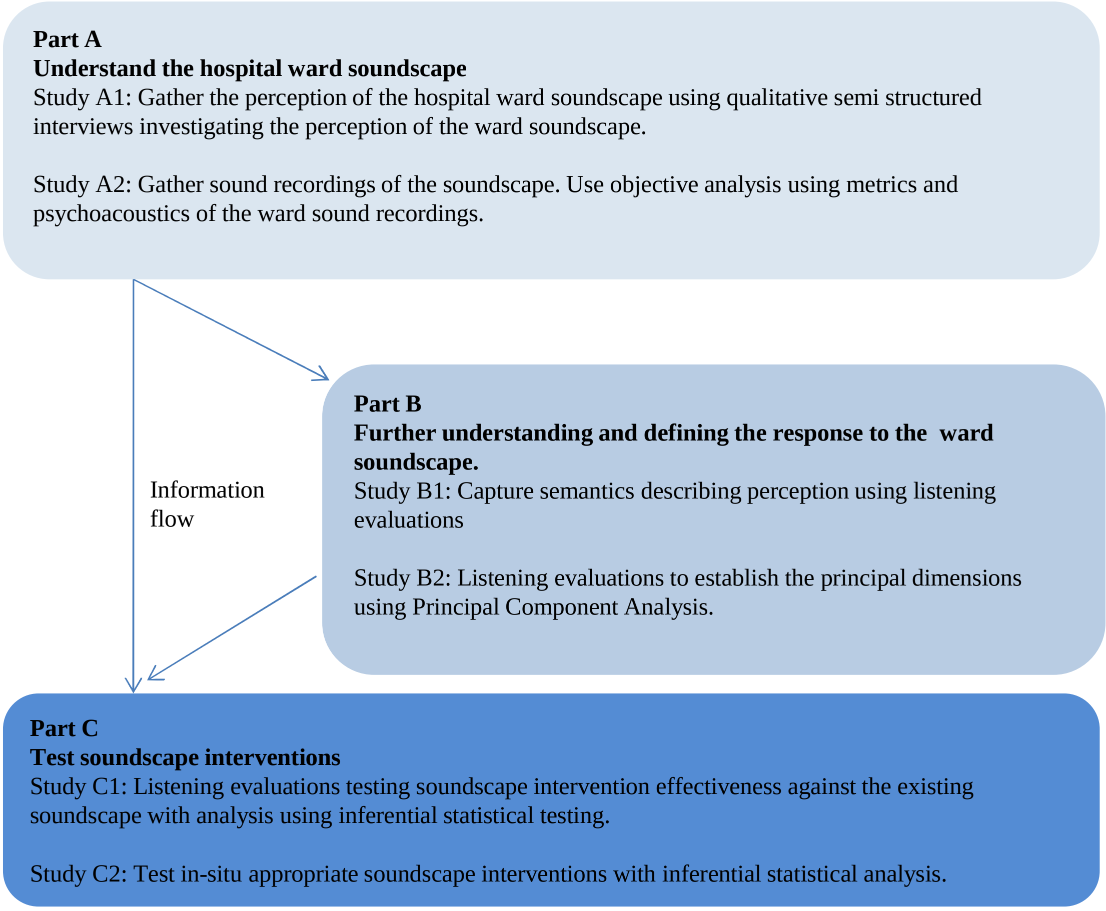
Furthermore, centring the research on users ensured that their thoughts and opinions were captured and considered throughout the research thus informing the 'design' of the soundscape. Arguably, the hospital environment is one such place where there are many different types of users and requirements. Therefore, this project aimed to assess the perception of soundscape from patient and nurse perspectives where possible.

The integration of theories from psychology and engineering allowed a holistic methodology to be developed to assess the healthcare soundscape putting the users at the fore. This is pertinent as there is a need to explore the degree, to which patients are comfortable, their thoughts on the influences on their health, wellbeing and recovery (Caspari et al., 2006) of which the soundscape is one environmental aspect. Importantly this takes a phenomenological stance, whereby focus is on the subjective experience of the individuals (Robson, 2007). Importantly, phenomenology can help make discoveries about the experiential world and aims to clarify situations and the meaning of experiences as the participant lived them (Giorgi & Giorgi, 2003). In this case this approach investigated the *perception* of the hospital soundscape along with how to improve perception through measuring the resultant feelings. Furthermore, the approach used acknowledged a reliance on scientific methods to test hypotheses and generate data along with the recognition that people and environments do not exist in isolation (Sanders & McCormick, 1992, p, 5).

3.2. Research Methods Summary

Many different approaches have been used in soundscape assessment, as discussed in chapter 2. The project adopted a mixed method approach by combining qualitative and quantitative measures which, Payne et al., (2009) suggests create a more complete description and evaluation of a soundscape. Furthermore, the method of combining in-situ and laboratory data was used given the difficulty in simulating situations involving complex sound sources (Yang & Kang, 2005) along with the pragmatic issues of hospital based research. In support, Payne et al., (2009) suggest that when analysing a soundscape from a psychological point of view, generally qualitative and/or quantitative methods are used to ascertain the subjective response and occasionally both objective and subjective methods are combined. These approaches offered a means to comprehensively assess the soundscape of the hospital ward environment utilising the benefits of both methods.

In order to address the gap in knowledge a sequential research strategy was used combining methods derived from both psychology through assessing perception in a qualitative way, and engineering, by producing perceptual spaces with which to map and test positive soundscape interventions. The project adopted a three stage approach highlighted in Figure 4. The objectives were derived and arranged to maximise the learning from each step to build a robust answer to the research question and exploit opportunities to explore new areas that arose.



Part A
Understand the hospital ward soundscape
Study A1: Gather the perception of the hospital ward soundscape using qualitative semi structured interviews investigating the perception of the ward soundscape.

Study A2: Gather sound recordings of the soundscape. Use objective analysis using metrics and psychoacoustics of the ward sound recordings.

Part B
Further understanding and defining the response to the ward soundscape.
Study B1: Capture semantics describing perception using listening evaluations

Study B2: Listening evaluations to establish the principal dimensions using Principal Component Analysis.

Part C
Test soundscape interventions
Study C1: Listening evaluations testing soundscape intervention effectiveness against the existing soundscape with analysis using inferential statistical testing.

Study C2: Test in-situ appropriate soundscape interventions with inferential statistical analysis.

Figure 4. Research stages with associated data collection methods.

3.2.1. Methods for Part A: Understanding the hospital ward soundscape

Stage 1 was a predominantly a qualitative element of research. Although the overriding stance of the research was not grounded theory, a notion of it was used in that the study used a bottom up approach concentrating on generating theory and information, here on the hospital ward soundscape, rather than test a particular theoretical content (Patton, 2002), for example urban soundscape knowledge. This was to gain information about the perception of the soundscape from key users of the space. This highlighted the phenomenological approach as the aim was to capture as closely as possible, the phenomenon (the soundscape) within the context in which the experience took place (Giorgi & Giorgi, 2003, p, 27), in this instance a hospital ward.

In study A1, a semi structured interview was used to understand the perception of the cardiothoracic ward soundscape from patients and nurses. Indeed, such an approach facilitates rapport/empathy, allows greater flexibility of coverage of topic, and tends to produce richer data (Smith & Osborn, 2003, p, 57). Furthermore, both groups were recruited to deliberately interview those who may hold diverse views on the topic to avoid biasing the data (Yin, 2011, p, 88). The approach enabled the thematic coding of the interviews to extract key notions from the data. A thematic conceptual model - the ordering of themes (Williams & Vogt, 2011) - of soundscape perception was made to visualise the key findings of the study and underpin the direction of further work.

Complementary to this, in study A2 objective measures were made assessing the acoustic and psychoacoustic attributes of the soundscape. Recordings of the soundscape were taken from a number of locations within the ward using a Bruel & Kjaer Sonoscout binaural recording device (Figure 5). A coding method developed by Poxon et al., (2009) of coding features of a soundscape from recordings over 1 second interval, was used to evaluate the soundscape in terms of sources and corresponding metric attributes. The data was used to support the findings of the interviews and assisted in the design of quantitative listening evaluations to meet objectives 2 and 3.

Figure 5. Binaural recording device used to record and analyse the CT ward soundscape.

3.2.2. Methods for Part B: Further understanding of perception

The methods of the project then moved on to quantitative analysis once an understanding of the soundscape had been achieved. To meet objectives 2 and 3 listening evaluations in a sound room laboratory were used to provide a controlled environment in which to gain a deeper understanding of the perceptual response to the CT soundscape. Similar research environments are often used to understand of the underlying nature of sound quality within the automotive context as listening room evaluations provide further insight into how customers evaluate the sounds of their vehicles (Jennings et al., 2010; Kim, Lee, & Lee 2009; Susini et al., 2009). Such listening room environments enable a more rigorous evaluation approach and are better suited to untrained subjects (Jennings et al., 2010). This method was highly applicable as most subjects were unfamiliar with the sounds of a hospital ward environment. Moreover, this evaluation method allowed multiple stimuli to be presented.

For this stage, the aim was to define the perception of the CT soundscape thus, adopting comparable approaches of soundscape practitioners (Hall et al., 2011; Guillen & Lopez Barrio, 2007; Cain et al., 2013). This also links to the area of Kansei engineering which considers and uses customer feeling and demands in product design (Nagamachi, 2002). Moreover, this technique utilises the semantics people use to describe products and their associated feeling in the design process. This is comparable to much of the soundscape work reviewed thus far. As such, the techniques of this discipline were used to develop questionnaire formats. These techniques provided a basis to utilise the qualitative interview data in a measurement tool to assess the response to sound clips from the CT ward.

Study B1 used the listening evaluation technique to capture language that described the perception to the soundscape and the feelings it elicited. In study B2 Principal Component Analysis was used to analyse the results of a semantic differential scale questionnaire based on the results of study B1. This approach exploited the language used to describe the soundscape which the analysis revealed are the emotional cognitive dimensions of the soundscape. This perceptual space expanded on the phenomenological stance of the project by creating a measurement tool which related to the perception of the soundscape.

3.2.3. Methods for Part C: Testing positive soundscape interventions

The emotional cognitive response and perceptual space allowed soundscape interventions to be benchmarked against the existing soundscape to assess their effectiveness in improving perception. Furthermore, understanding how positive a soundscape is can be more easily done by comparing soundscapes rather than giving an absolute answer (Jennings & Cain, 2012). In study C1, a repeated measures design was used to test interventions which were chosen based interpretation of the interview data and supporting literature. This allowed inferential statistical testing using a repeated measure Analysis of Variance (ANOVA) to draw conclusion from the data. The approach provided a robust method and reference point with which to compare and contrast findings to other soundscape work for example Cain et al., (2013) and Axelsson et al., (2010).

To conclude the work, an in-situ evaluation was carried out in study C2. Using a questionnaire analysed in a quantitative manner this tested a selected soundscape intervention in-situ. This study drew upon the unique environmental context and demographics of the hospital ward. Indeed, in-situ methods provide more nuisances and complexities relating to sound in a given environment (Payne et al., 2009) which this small study acknowledged. This explored the ecological validity of the findings of the project and tested the pragmatic aspects of the developed interventions in creating a positive soundscape within the context of the hospital ward.

3.2.4. Arrangement of methods

Support for this triangulation of techniques comes from Morse (1991) in that one way to arrange mixed method research is to have a sequential approach, starting with qualitative element and then draw upon the attributes of quantitative testing. This is particularly useful to test emerging hypothesis and determine the distribution of a phenomena within a population (Morse, 1991). The approach also validates subjective data in a robust way through using experimental evaluations. Moreover, this mitigates against the disadvantages of concentrating on either in-situ or laboratory evaluation in terms of the perceptual variation between sounds heard between the two settings (Payne et al., 2009). As Payne et al., (2009) advocate, employing this approach means the reaction and perception to sound components can be explored in more detail and arguably is more robust as a result.

3.2.5. Sample characteristics

The in-situ studies involved CT ward patients and nurses. The aim of both these studies was to capitalise on these individuals to ensure, as Giorgi & Giorgi, (2003) state, that the meaning of the experience was as participants lived them. As a results, recruitment utilised purposive sampling as the purpose for selecting these study units was to obtain those that would yield the most relevant and plentiful data (Yin, 2011, p, 88). As such these two groups were specifically targeted for recruitment.

In contrast, for the listening evaluations, convenience sampling was used, defined as selecting sample units because they are readily available (Yin, 2011, p, 88). As such, members of the University and wider community were recruited for this stage. It is acknowledged that this has some limitations. Yin (2011, p, 88) points out that they are not likely to be the most informative sources and can cause an unwanted degree of bias. However, in argument for their use, obtaining a CT patient sample for use in a laboratory listening evaluation is not feasible. These patients are too ill to travel and recruiting patients after they had been discharged has ethical issues associated with the disclosure of information along with a protracted timescale. Therefore, although not a representative sample their use was justified when considering pragmatic constraints. Furthermore, demographic issues in soundscape evaluations, for example the variance in perception, mean it is therefore necessary to obtain a large sample to account for the variation in nuances (Cain et al., 2013).

In further support of this, the data from the initial interview stages was then used throughout each subsequent stage, along with the sound recording obtained from CT ward. Therefore, listening evaluation participants were rating the soundscape based on language patient and nurses described their perception of the CT soundscape. Moreover, any individual has the chance to become a patient. Indeed, within the UK the Department of Health (2009) acknowledge this when advocating participation in the design of health service stating;

> *"We will all, at some point, use an NHS service, so we all have a unique perspective that could help make care better (DoH, 2009)."*

Therefore, healthy participants can assist in the design of these spaces as they may be future users of hospital environments.

3.3. Research Venue and Pragmatic Issues

3.3.1. National Health Service (NHS) Research Ethics Approval and Research location

In order to carry out research in an NHS UK public hospital it is necessary to obtain research ethics approval. University Hospital, Coventry part of University Hospitals Coventry and Warwickshire NHS Trust (UHCW) was chosen as the research venue due to its convenience and proximity to the University of Warwick. Full NHS research ethics approval was obtained from Birmingham East, North and Solihull Research Ethics Committee who reviewed the research protocol for its ethical merit (appendix 1). After discussion with the Research and Development manager at UHCW it was decided that the CT ward would provide the most appropriate environment with which to conduct the research (Figure 6).

Figure 6. Images of the CT ward; main corridor top, patient bay middle, inside patient bay bottom.

The CT ward treats patients who undergo heart surgery. As a result, the ward has a diverse range of equipment and areas which creates a soundscape similar to an intensive care unit but enables patients to be actively involved in the research process. Importantly the ward consisted of two areas. The main area (corridor and patient ward bays) are where pre and post-operative patients are present (Figure 7) and the step down area, where patients who had come out of ICU after surgery initially recover (Figure 7). The research was conducted in both these locations with the step down area containing more monitor and breathing devices creating a slightly different soundscape to that of the main area. This fits as much of the previous research such as Xie & Kang (2010) and Thorgaard et al., (2005) assessed sound within acute care areas. Comparison and contrasts with such work could therefore be made.

The listening evaluations were also subject to research ethics approval. The Biomedical Research Ethics Committee at the University of Warwick reviewed and approved the protocol detailing the listening evaluation procedure.

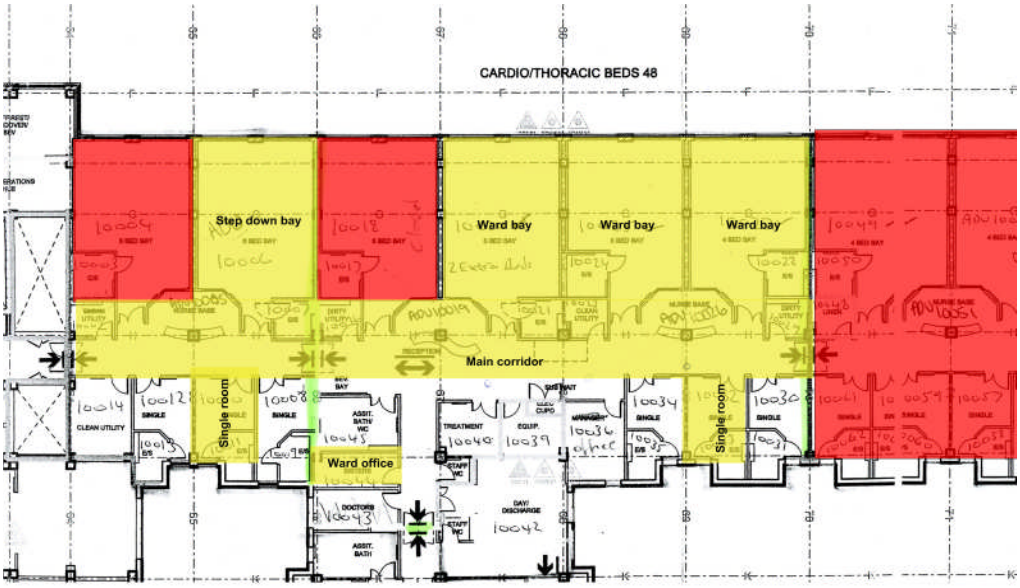


Figure 7. Plan of the CT ward showing the areas where the research took place (marked in yellow). *Note*, red areas mark no access permitted for the research.

3.4. Summary from Chapter 3

This chapter has given an overview of the methods used within the project. These were used to as a whole to build a robust answer to the research question. Therefore, the qualitative and quantitative elements of the work exist together rather than being mutually exclusive.

CHAPTER 4

PART A: UNDERSTANDING THE HOSPITAL WARD SOUNDSCAPE

4.0. Introduction

In order to appreciate how improve the CT soundscape it was necessary to capture thoughts and opinion of it first-hand. In Part A an interview study was used to explore the subjective experience of sound in the ward. Part B discusses a short section on the objective attributes of the soundscape to provide comparisons with existing literature on the acoustic attributes of the wards soundscape.

4.1. STUDY A1: UNDERSTANDING PATIENT AND NURSE PERSPECTIVES OF THE CT WARD SOUNDSCAPE

To build a comprehensive understanding of the perception of the soundscape a qualitative approach was used. This explored the character of the soundscape within the CT ward and the subjective response to this. The study used in situ interviews with both clinical nurses and patients, based within the CT ward. This allowed perceptions of sound and other environmental attributes to be obtained first hand without bias from researchers' preconceptions. The results importantly, were used to develop further research avenues based on the outputs of the study.

4.2. Method

4.2.1. Interview development

In order to retain a certain degree of control, a semi-structured interview schedule was developed (Appendix 2.1/2.2). Semi structured interviews are widely used in flexible qualitative designs (Robson, 2005) which the study aimed to utilise. Robson (2005, p,271) cites King (1994) to suggest this is most effective when exploratory work is required before a quantitative study can be carried out which can assist in clarifying the meaning of findings.

In accordance with Robson (2005, p,270), the interview schedule contained predetermined questions but the order was modified based on what seemed most appropriate at the time. Interviews began with questions regarding the general ward environment. These were used as ‘warm up’ questions (Robson, p,277) to get participants to think about the environment in general rather than focus specifically on sound. This further assisted in participants becoming relaxed in the interview process. After this questions moved on to the tackle the main aim of conducting the interviews – the soundscape. This was the ‘main body of the interview’ (Robson, 2005, p,277) and covered the soundscape specifically using questions to probe the notion of sound and highlight positive and/or negative aspects. Finally, as Robson (2005, p,277) suggests ‘cool off’ questions ended the interview and involved asking how the participant felt that the environment could be improved.

4.2.2. Pilot interviews

The interview schedule was tested on a pilot sample of seven healthcare professionals before the main data collection period using telephone based interviews. The aim of this was for the researcher to gain experience with the interview process and assess the success of the schedule in providing the required data. As a result, no modifications to the interview schedule were made but the coding procedure was refined. This helped ensure the procedure was constant across participants and limited variation in the procedure, wording, briefing all of which ensures data quality (Oppenheim, 1992, p,148).

4.2.3. Study interviews

The study took place over a one month period in the summer months between June and July 2010. Interviews ranged from 7-19 minutes in duration. Patients were interviewed at their bedside within the ward bays with two patients in single rooms off the main corridor. Interviews with nurses were held within the ward managers' office just off the main corridor. All interviews were started with a prewritten script detailing the aims of the study to maintain constancy between the participants. All were recorded on an electronic Dictaphone and transcribed verbatim. Participants were informed of the aims of the study via an approved participant information sheet. Informed written consent was obtained (Appendix 2.3) from each participant prior to the interview.

A total of 27 participants were interviewed with the sample size dictated by reaching theoretical saturation defined as the point upon which no new properties, dimensions or relationships emerged from the data (Strauss & Corbin, 1998). Eleven patients were interviewed, nine male and two female, with a mean age of 68yrs (S.D 11.7). Patients had an average stay of 6.8 days (S.D 4.3) in the ward. A total of sixteen female nurses were interviewed with an average age of 42.6yrs (S.D 12.4) and average experience of 19yrs (S.D 10.8) working in hospital environments.

4.2.4. Analysis

Interview transcripts were coded using Thematic Analysis to extract the key themes and categories - smaller ideas held within a theme – from the data. The form of coding is suggested as part of a Grounded Theory approach by Strauss & Corbin (1998) which builds theory rather than tests an existing theory. Although grounded theory was not used to underpin the research methodology, here it was necessary to build an understanding of the perception to the soundscape. Indeed, Davies et al., (2013) comment this is an inductive and iterative approach that involved subjectively applying codes on sections of the text on repeated readings to progressively build a picture of the main themes and ideas in the discussion, here the CT soundscape. This process was carried out after the first three interviews of each group (patient and nurse) to define the emerging themes and categories. The coding schedule was developed by methodically analysing each transcript, continuing until theoretical saturation was met.

Coding was carried out by hand without the aid of qualitative data analysis software. Once an initial coding framework had been developed this was refined and checked by re-coding the transcripts a further three times. An external reader (a colleague) then analysed three randomly selected interviews transcripts to verify the validity of the coding, upon which the framework was refined and all transcripts re-coded. Frequency counts of final codes were made to show the major themes and trends within the data. The analysis then moved on to the most important stage of axial coding. This aspect of coding was used whereby related themes and categories were explored (Gibbs, 2007) and constructed forming a conceptual model. As a result this allowed a more analytical and theoretical explanation (Green & Thorogood, 2009) of the results.

4.3. Results and discussion of Conceptual Model

The study was successful in enabling both patients and nurses to articulate their views on the soundscape of the ward. The interviews produced engaging dialog with the participants despite the variation in duration, and rich data describing the perception of sound. This facilitated a variety of different views to emerge from the data revealing 11 key themes as a result. These were subdivided into 42 categories upon which theoretical saturation was achieved (table 2). Unsurprisingly due to the stance and structure of the interview schedule, perception of sound was the predominant feature. The full coding schedule developed is shown in Appendix 2.4 detailing themes and categories.

Theme	**Frequency of comments within theme**
Perception and influence of sound - Comments regarding the perception of sound within the environment and the effect upon the individual.	319
Sound Sources - Comments regarding sound sources within the environment and perceived sound level.	136
Emotional response - Comments/words describing the emotional feelings of the individual as a rest of sound or another environmental attribute.	102
Temporal factors - Comments on how time affects the perception of environment and sound.	76
Restoration - Comments relating to the concept of restoration provided by components of the environment.	65
Other Physical attributes - Comments on how time affects the perception of environment and sound in relation to activities and perception.	55
Comments about future design - Comments, considerations and suggestions about the design of future healthcare spaces.	44
Behaviour of people - Comments on how the behaviour of people affect the perception of the environment	24
Analogy - Description of the perception of the environment and/or environmental attribute which is described using an analogy.	10
Job duties - Comments regarding clinical duties.	8
Patient interaction - Description of patient interaction within the ward.	8

Table 2. The final coding framework and themes with frequency of comments from the 27 interviews. *Note,* frequencies shown should be interpreted in relation to each other.

Figure 8 presents the conceptual model that developed from the axial coding stage. This represents the most salient points from the interviews constructed in a rational manner to show the perception of the ward soundscape. The model depicts how the soundscape not only influences the individual subjectively, but also the dependencies on the context of both the physical and social environment. Indeed, hospitals are behaviour settings where there is a definite relationship between people and the built forms of hospital (Gesler et al., 2004). The components of the model are supported from patients (*P*) and nurses (*N*) comments. These proved to have some similarities and differences when discussing their perception towards the soundscape. Below, each component of the conceptual model is discussed in sequential order, from cause (sound sources) to response. These links explain the logic and theoretical interpretation of the findings.

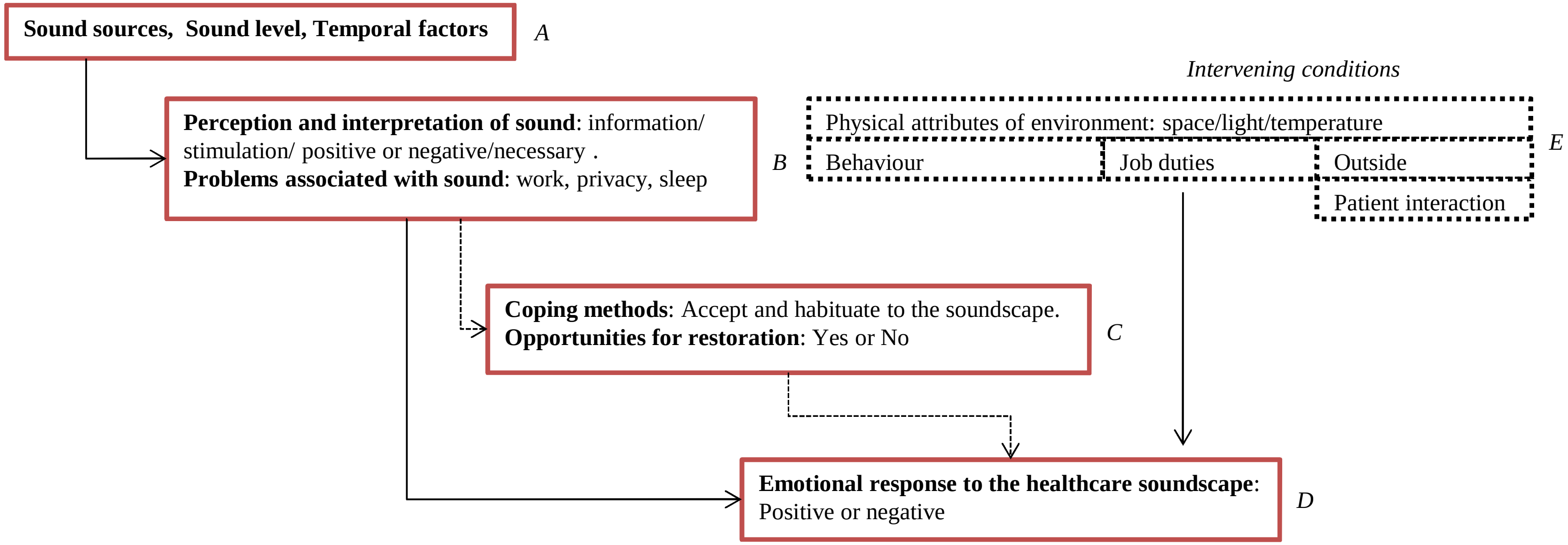


Figure 8. Conceptual model of hospital ward soundscape perception developed from interview data with patients and nurses showing key factors in perception.

4.3.1. Section A: Sound sources, sound level, temporal factors

Firstly, the model distinguished the causation factors that create the soundscape; the sources, an associated acoustic parameter and the relationship with time. The sound sources are fundamental to perception as they trigger the communication between the environment and the individual. Within the ward setting this was expressed clearly by nurses:

> *N: I feel with my ears I'm constantly listening out.*
>
> *P: Just a continuous cacophony of wheels, trolleys alarms going off.*
>
> *P: Well here you get them cleaning the floor with the machine, trollies coming down, beds being moved, there is something going on all the time.*

Of these sources human generated sounds were reported most *(67%, n=18)* including those of patients, nurses and visitors. Specifically, these were sounds of verbal conversation, laughing, and coughing. Such sounds and their character help define the ambient soundscape which one nurse remarked was simply *"a lot of conversation all the time"*. Along with this, intermittent equipment and occupational sounds were frequently mentioned by nurses and patients *(52%/41%, n=14/11 respectively)*. As nurses work between spaces they are possibly more aware of cleaning equipment, doors, trolleys and general day to day activities due to their interaction with them. Coupled with this, sounds from outside heard *(30%, n=8)* through windows which overlook a green space, wood, and car park were mentioned by patients, as well as bedside TV and radio systems.

Theme and category	**Frequency of comments**	
	Nurses	Patients
Sound source people	17	17
Sound source equipment	28	8
Sound source occupational	30	16
Sound source outside	2	5
Sound source entertainment	8	3
Sound source other	0	2

Table 3. Showing the concepts within the sound source theme. *Note,* the frequencies shown should be interpreted in relation to each other.

Depending on the individuals' role, the influence of the soundscape varies. Nurses remarked that sound affects their ability to work, particularly in relation to job duties and speech intelligibility. This began to highlight the notion of sound level:

> *N. It's a noisy environment. A lot of the equipment makes noises and alarms. Particularly in step down[1]. What else? Really equipment and nurses. Patients voicing pain and the thoroughfare. The buffer, the cleaners use, drives me insane. With the phones going and the buffers going it's quite stressing.*

This sense of sound level was a latent concept that emerged. Many of the nurses described the environment as *"noisy" (44%, n=12)* interpreted in context as loud. Conversely, some patients found the environment to be relatively quiet *(30%, n=8)*, signifying that the perception is subject to individual differences and personal preferences, particularly in the case of patients. This was seen as positive and negative depending on the time of day.

> *P: One thing I have noticed at this hospital is that it is quiet. I like that, it allows you to relax.*

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[1] Step down is the area of the ward where patients who come out of intensive care first begin recovery. This consists of a greater number of monitoring devices and a greater staff presence as patients are more acutely ill.

> *P: Now this particular hospital is very quiet and therefore, if you wake up [at night] and you don't hear general noise you start wondering.*

The term "noisy" may also infer that there are a number of sound sources within the environment, creating a mixed soundscape in terms of sources, level, content and the subsequent communication to the individual. Indeed, 'noise' is a subjective appraisal of an unwanted sound (Plack, 2005). Two patients described the soundscape as *"a lot of hard noises like in a kitchen"* and "*Sainsbury's [a large UK supermarket chain]"* going some way to reflect the variety of sources.

Analogies provide a description of how the individual relates the soundscape to their personal experiences, and subsequently form a richer understanding of it. From these descriptions it can be said that there are a variety of intertwined sources. Therefore, individuals within the soundscape interpret much information from these sounds known and unknown, which concurs with Rice (2003) statement that hearing becomes pronounced in hospitals:

> *P: You've got time to lie there and all you've got time to do is to listen to what is going on.*

The final causal condition the model acknowledges is that of time. Sound exists in time and influences the sense of time with the character of an environment tied to this relationship (Truax, 1984). Evidence of this came from patients and their comments to suggest that temporal variation of the soundscape provides a positive stimulation. Such notions are valid as the healthcare experience is perceived as a visual, auditory, and temporal experience (Mazer & Smith, 1998). Temporal variation provided a positive effect (n=19) and relieved the sense of *"boredom in the atmosphere":*

P: You've got time to lie there and all you've got time to do is to listen to what is going on.

N: It's [sound is] different at different times of the day. So very first thing in the morning when I come on at 7o'clock it quite quiet and quiet relaxed because the patients are just getting up. But then from 9 -11 o'clock it's very busy because you're helping patients with their care.

P: After a while, you…the day gets split up into tiny proportions and you wait until the next event. First thing when you wake up you know the tea is coming round at 6 o'clock...and you hear it. It's a fantastic sound.

P: [Time is] comforting in a way...there's a routine going on...it's the heartbeat of the hospital.

4.3.2 Section B: Perception of sound

These almost physical attributes feed into the more subjective appraisal and response of the individual. The soundscape, at any one time, could be perceived as positive, negative, or necessary whilst containing information or stimulation (table 4).

Theme and category	**Frequency of comments**	
	Nurses	**Patients**
Perception of sound general comment	5	4
Perception of sound positive	11	15
Perception of sound negative	17	33
Perception of sound in background	24	10
Perception of sound accept or habituate	25	26
Perception of sound necessary	10	3
Sound source description of sound	7	11
Sound level high	31	17
Sound level low	5	14

Table 4. Showing the categories within the perception of sound theme.

Unnecessary sounds were generally considered negative by patients *(n=4)*, for example, blood pressure monitors left on without application:

> *P: I don't mind it when it's noisy...when there is a reason for the noise.*
>
> *P: Well there is a certain amount [noise] like the beep beep but it's when it's [equipment] just hanging waiting and still switched on, that's the annoying bit.*

Specific sources perceived negatively by patients and nurses, were generally occupational sounds (floor cleaning machine, trolleys and loud talking) *(59%, n=16)*. Additionally, nurses highlighted that the doctor's ward round generated "*an intimidating sound*" although it is unclear if this was considering the patients' point of view or not. As has been remarked there are individual variations, as what may be positive for one is negative for another. Music from patient television sets was one such sound source. Xie & Kang (2010) found nurses like music, concurring with the positive statements here *(n=6)*, yet this was not a uniform view:

> *P: I don't like background noise [referring to music]. I'm not a background noise person.*
>
> *N: Music makes you forget where you are, it's a happy noise.*
>
> *N: Sometimes that [music] can be nice but sometimes the din that comes through can drive you barmy.*

This interpretation and processing of the soundscape suggests a cognitive appraisal occurring, a theory which Eysenck & Keane (2000) states is crucial in the emotional experience of a stimulus. For example, unnecessary sounds are possibly negative because they hold information which holds little value to the patient. As such, the soundscape relates to several of the cognitive appraisal components proposed by

Smith & Lazarus (1993). In this an environmental stressor can be appraised and coped with as emotion-focused coping (psychological coping) (Folkman, 2008). This relates to the temporal aspect of the soundscape. This appraisal appeared somewhat driven by the notion of control, with control here being defined as thoughts and actions to cope with a stressor (Schreuder et al., 2012). Sounds providing specific information facilitated this. For nurses, as information is provided by alarms and monitors, it can be postulated that there is an element of psychological control – they are meaningful - and so the sounds are positive. From a patient perspective the sound of an innocuous trolley also provides information:

> *P: When I hear the breakfast trolley come I'm like one of Pavlov's dogs. It's an encouraging noise. I can distinguish between the tea trolley and the breakfast trolley.*
>
> *P: The tea trolley is a particularly pleasing sound [laugh].*
>
> *P: You can hear the trolleys coming down with your drinks. That's nice because you know you're getting a drink!*

In the case of patients this suggests implicit learning of these events, as the soundscape provides cues which affect perception and in turn the somewhat emotional response, which Irwin et al., (2011) support. Truax (1984) observes that pattern of familiar sound, through repetition, enters the long term memory when combined with the environmental context. Therefore, implicit learning of the soundscape through exposure to it leads to an increased understanding provided by the cues of the soundscape and the temporal experience. In an example of this, information about a specific sound can ease the negative feeling and feed this implicit learning.

> *P: When I first came in and the poor old lady was screaming it is rather upsetting and until somebody explains you think that somebody is hurting.*

Here, learning and information changed negative feelings into an accepted and habituated state. This was accentuated when music, despite the subjectivity, was played within the ward to calm this patient:

> *P: In the afternoon they put music on for her [fellow patient who was distressed with Alzheimer's disease]. It's quite low but we can just about hear it. Now that makes us feel better.*

Consequently, hospital sounds can provide a positive effect as long as they are accepted and understood within the context of the environment. This promotes the emerging idea of the importance of information in order to interpret the ward soundscape positively. Information links to Topf's (2000) stress model which advocates that if patients have access to information they find the environment to be less stressful. This is associated with elements of control they feel they may have towards the soundscape. Potentially, this moves the soundscapes locus of control from external to internal, where individual perceives that she/he has control over the event (Schmitz et al., 2000) which Folkman & Lazarus (1993) would suggest is emotion focused coping.

Supporting this interpretation, Lundberg & Frankenhaeuser (1978) showed that with regards to noise intensity, individuals with internal locus of control showed lower stress levels when they had control over the noise intensity whereas 'externals' exhibited the reverse reaction. Although in this example participants had physical control, it is a tentative way of demonstrating that it appeared that information can assist as a coping method in a psychological manner towards sound.

4.3.3. Section C: Coping method - accepting and habituating to sounds

This leads on to the most important aspect of the model, coping methods. The perception of stressor (here the soundscape) and the response to it determines coping behaviour (defined as thoughts and actions) which may be a habitual behaviour (Schreuder et al., 2012). Therefore, if the sounds are understood, accepted, and then habituating to, the perception is more positive. Gleitman, Jonides, & Rozin (2004) describe habituation as a decline in an organism's tendency to respond to a stimulus once the stimulus has become familiar. Using the example of sound Gleitman, et al., (2004) comment, a sudden noise startles, a second time the startle is diminished, a third time, will hardly evoke a response and after that it will be ignored all together. This appraisal begins to shape the emotional response to the soundscape and demonstrates Smith & Lazarus' (1993) emotion focused coping as individuals deal with the sounds of the ward psychologically. Both nurses and patients accepted the sound within the environment as part of being in hospital (74%, *n=20*) and for patients, although novel at first, they become accustomed to it exhibiting this habituating characteristic:

> *N: Like now it's noisy out there but you can get on with your work because you know what the noises are there for a reason.*
>
> *N: [The sounds are] How it is.*
>
> *N: It's definitely a case of these are the sounds in your work place and you accept them. You have a sort of level of tolerance that they are below if you like.*
>
> *N: The sounds you can hear, we just forget them.*
>
> *P: It's just part of being in hospital. You can't expect people to be quiet. It's just acceptable.*

P: [Sound] you get used to it.

Habituation to sounds within the environment is not surprising as comprehension of the soundscape increases as information from sound enters the person's memory. Truax (1984) cites Campbell (1983), that habituation syndrome occurs in peoples' response to noise, whereby at first they find it annoying but then it is too much trouble to do anything about it so they become accustomed to it. Indeed, Davies et al., (2013) suggest habituation to commonly heard sounds within an urban soundscape explains individual differences in response. This supports the findings here in reaction to the CT soundscape and supports the application of Smith & Lazarus' (1993) cognitive appraisal theories as discussed.

The periodic regularity of the soundscape defined by the daily routine of the hospital assist this. As a result, the same sound sources are present during these events, facilitating implicit learning and habituation. Indeed, it has been found that patients who had been in ICU two or more times were significantly less disturbed due to hospital sound than those who had not (Akansel & Kaymakci, 2008) suggesting a level of habituation to hospital sounds.

If these coping methods cannot be achieved then the response appeared more negative (*n=3*). A lack of habituation was cited when commenting on other patient sounds suggesting that the meaning behind the sound is an important determinant. The sounds associated to the Alzheimer's patient were accepted because they were understood and applied to *help* the patient. As a result, regular patient sounds may not be as easily accepted and habituated. Indeed, susceptibility of disturbance due to noise is dependent on many factors including age, sex, and experience (Muzet, 2007):

> *P: [Patients] coughing and spluttering and all the rest of it, stuff like that. It's very distressing.*
>
> *P: The worst thing was a man who had had his heart operation and was having to cough up all night in the bed next to me. And that was disturbing because I couldn't sleep.*
>
> *P: Obviously when you're on a ward as well there are people's bodily functions at various times which are a little bit disconcerting.*

4.3.4. Section D: Positive or negative response to the hospital soundscape

In this study, the emotional response was defined by positive or negative semantics describing the individuals' feelings' as a direct result of the soundscape, for example, "*distressing*". More positive responses and comments were noted from patients *(31)* than nurses *(19).* The description of coping methods demonstrated how this process improved feeling with more positive responses notes from patients *(26%, n=7)*:

> *P: The gentle hum of people doing things is good because you don't feel like you're detached. You're part of what is going on.*
>
> *P: Nurses and doctors chatting and knowing you're being looked after…reassuring.*

Positive emotional response also come from notions of restoration (table 5), defined as a factor that contributes to reducing stress, promotes positive moods and feelings, and may facilitate recovery from illness (Laumann et al., 2001).

Theme and category	Frequency of comments	
	Nurses	Patients
Emotional response positive	19	31
Emotional response negative	31	21
Theme and category	**Frequency**	
	Nurses	**Patients**
Visual aspect restoration	2	9
Sound Restoration	25	16
Outside stimulation	1	12

Table 5. Showing the categories within the emotional response and restoration theme.

A period of ‘quiet time’ was in place in the ward. This was a one-hour period after lunchtime where activities were kept to a minimum to allow patients to rest thus controlling occupational sound. The aforementioned sense of restoration for both patients and nurses was provided as a result. Nurses clearly stated the benefit of this period *(44%, n=12)*:

> *N: Everything is much much calmer. Phone calls happen but I don’t feel stressed because it’s quieter.*
>
> *N: Patients are resting; nurses have settled back into their routines and got rid of all the chaos. You can concentrate.*
>
> *N: A recharging time for both patients and nurses.*
>
> *N: It’s peaceful. It’s much more calming.*

This enabled nurses to have a break from the general soundscape and concentrate with fewer sounds. If individuals are fatigued mentally, which in this environment sound may be a contributor, they are likely to make more errors, have reduced productivity, and higher stress levels (Kaplan, 1995). As a result ‘quiet time’ provided “*a recharging time*” for them - a restorative element. Patients express a similar view as it resulted in an overall positive feeling *(30%, n=8)*:

> *P: It helps with the healing process, I’m sure it does.*
>
> *P: I think it’s very important to have quiet time.*

> *P It gives you a chance to relax. Sixty winks sort of thing before it [the sounds] all starts again.*

The control of occupational sounds may have more subjective meaning to people as individuals are actively altering the soundscape which aids a sense of control they may feel they have towards the soundscape. This concurs with Gardner et al., (2009) who concluded that the overall strongly positive response from patients, visitors and staff suggests that scheduled quiet time would be a positively perceived intervention.

Additional positive feeling was evident in hearing birdsong through the windows of the ward that overlooked a green space. This combination of seeing and hearing nature was seemingly important and was always associated with a positive emotional feeling. This relates partly to the biophilia hypothesis – attraction toward nature - which soundscape practitioner Guastavino (2006) advocates when commenting on the positive association of natural sounds. Supporting this, Pheasant et al., (2010) found that in an auditory experiment, biological sounds (a living non-human organism) had a positive influence on ‘tranquillity’ defined as a quiet, peaceful, and attractive place to be. Furthermore, Pheasant et al., (2010) discovered that in an audio-visual experiment, biological and weather sounds were the only attributes that significantly positively influenced the perceived tranquillity of a view. Using this as an explanation, there was a bio-modal interaction showing the positive effects of auditory-visual congruence in seeing and hearing nature within the ward *(19%, n=5).*

> *P: It’s gorgeous here because I have the birds [pointing out the window] and when they open the windows and things like that it’s gorgeous - ideal that situation.* ***So do you like hearing birds singing?*** *Yeah this is lovely this is here, beautiful, beautiful.*

P: It means so much to me. When I was in the other ward (ICU) *it was enclosed. As soon as I came in here I though ah trees. I love to see trees and greenery. That's brilliant…for me personally that's a big thing to overlook something quiet, serene I suppose. Nature, it calms me"*

N: It's nice because we've got views of the fields…it's nice and the wildlife and everything you can see.

Based on this evidence the perceptual response to the soundscape will be more positive than the baseline feeling if the individual is able to accept and habituate their response. Enhancement of this would come from the presence of a positive sound, for example, birdsong and opportunities for restoration through 'quiet time'.

4.3.5. Section E: Intervening conditions

Intervening conditions influence the perception of the soundscape and define the context in which the soundscape is heard, either physical (for example, light and temperature) or social (for example, human behaviour and work duties). The presence of such conditions contributed to either a positive or negative emotional response. For instance, temperature and lighting affected the mood of nurses and patients *(37%/30%, n=10/7 respectively),* which altered the perception of the soundscape. These environmental conditions therefore, potentially influence an individual's ability to cope with the soundscape:

N: You just get hotter and stickier and it just makes people a bit 'huff' you know.

N: Hot, it's too hot. **How does that make you feel when it's too hot?** Stressed.

N: lighting in the side rooms is chronic…they've [patients] got no light and they're in there for a few weeks there mood becomes sort of [no details given]...because of the lighting.

P: It's too hot, there's no ventilation…it's very unpleasant.

Likewise, the behaviour of people influenced the soundscape and the perception of it *(48%, n=13)*. This notion of behaviour affecting sound was highlighted by Topf (2000) who advocates educating staff in their understanding of sound and behaviour as a method to improve the sound quality of healthcare environments. Such behaviour, left individuals feeling ill-considered, contributed to a negative perception of soundscape, and thus emotional response. These contextual elements are considered in the model but their actual influence requires individual testing to accurately measure the relationship to soundscape perception:

> *N: Sometimes they're [staff] shouting in the walkie talkie, which is loud anyway and you're thinking they don't need to shout.*
>
> *N: [discussing communicating with patients] I do find that quite irritating…when people are talking over you and they don't seem to register "hello, I actually need to listen to this person".*
>
> *P: Someone comes crashing through at 3 o'clock in the morning with a trolley of rattling pots or something, smack into the door and you think did they really have to do that?*
>
> *P: You start nodding off then…someone's up and down the corridor and that wakes you up.*

4.3.6. Semantics describing the subjective response.

In order to understand the subjective experience further the semantic used to describe the personal response to hearing the CT soundscape were recorded. These were used to define a perceptual space describing perception described in Chapter 5. These subjective responses were described through various semantics (Appendix 2.5) clustered into positive and negative groups (table 6,7).

Selection positive words	**Selection negative words**
Calm, recharged, tranquil	Stressed, disrupted aggravated
Encourages, secure, reassured	Distressed, scared, intimidated
Engaged, bustling	Lack of concentration
Peace and quiet	Frustrated, annoyed, awful

Table 6. Selection of type of positive and negative semantics used by interviewees.

Semantic similarity was seen between the words both participant groups used relating to the expressive feeling towards the perception of the soundscape. Negative responses for nurses were expressed using language such as ‘irritating’, ‘disturbing’, ‘annoying’, and ‘frustrating’. The wider soundscape was described as ‘busy’ and ‘hectic’. Patients used words which related to their perceived comfort within the environment more than nurses with words such as ‘scary’, ‘uncomfortable’, and ‘startled’. Interestingly, patients recorded more positive words *(36 words against 29)*, suggesting that they accept the soundscape in a positive way, supporting the arrangement and theories of the conceptual model. Importantly, these semantics describe how individuals felt and therefore it can be suggested that a positive healthcare soundscape would be one which is perceived as ‘calm’ rather than ‘quiet’.

> *N: ...most days are quite busy, some days are quite intense, some days are manic. We never use the word quiet because that’s like saying Macbeth backstage, you just jinks yourself. We use the word calm. It would be nice if it was calmer.*

	Positive words	**Frequency**	**Negative words**	**Frequency**
Nurses	Calm	9	Annoyed	2
	Peaceful	3	Frustrated	2
	Relaxed	5	Horrendous	3
			Irritate	2
			Manic	2
			Stressed	8
Patients	Calm	2	Annoyed	6
	Comforting	3	Disturbing	2
	Lovely	4	Unsettled	3
	Relaxed	6		

Table 7. Frequency counts of most commonly used positive and negative semantics. *Note*, not all semantics included for brevity.

4.3.7. Considerations in future design

Although not part of the conceptual model, the final part of the interview asked participants to think about how they would improve the environment. This was used as a way to conclude the interview but allowed thoughts on improving the soundscape to be obtained first hand. Both patients and nurses mentioned sound in the considerations on future design, but with converse views. Many of the nursing staff suggest the use of a radio in creating a positive feeling and improving the soundscape:

> *N: I prefer music. If a patient has music on its quite nice to be in that bay. Not that its loud but it's just there as a background noise and I consider it better with that.* ***And when you have a background sound like that how does it make you feel?*** *Happy, cheerful... it brightens your mood. It doesn't matter what the music is, it's just there as a nice noise if you like.*
>
> *N: You do miss the radio...years ago we used to have a radio in the background just to chill people out which did work...just that bit of background noise.*

Another nurse stated that improvements to the soundscape would come down to the behaviour of people by being aware of the sound they make. The comments show benefits in terms of individual feeling and highlights the coping methods depicted in the conceptual model:

> *N: I think it's a case of managing the noise that we do make... unnecessary noise that we don't need. So it's case of getting people to realise its case of minimising what we do. And that then there is space in peoples coping mechanisms...You're not bombarding them [patients] with stuff that isn't necessary.*

This view supports many of the patients who strongly dismiss the idea of having additional sound within the environment:

> *P: Additive noise of whatever is not on. It's not on. It's like music in a hotel lift.* **Would you find it annoying?** *Well, it's artificial.*
>
> *P: My preference is for quiet...my positive sound for me is no sound.*
>
> *P: I don't like background noise. You need it quiet...I'm not a background noise person.*

These contrasts in opinion are particularly useful. It shows the necessity to explore potentially positive and negative sounds along with other intervention methods to establish what a positive soundscape comprises of and how it could be achieved.

4.4. Discussion

The conceptual model depicts sensitivity to the hospital ward soundscape acknowledging a diverse physical and social environment too. Importantly, it shows the transition from physical sound into the emotional response of the individual with various processes that may be adopted, for example, coping methods, with these underpinned theoretically. This aided the understanding of the soundscape and furthermore, looks beyond sound level considering the influence of the soundscape, and the processes of understanding this communication within the hospital context. Indeed, Gesler et al., (2004) state that architects and environmental psychologists focus on measurable components of the therapeutic environment such as noise (sound level) and fail to consider the more qualitative features, such as subjective feelings.

The established theories of cognitive appraisal and learning, that underpin the interpretation of the conceptual model, provide a rationale to experimentally manipulate perception through physical and cognitive means. This would potentially improve the perception of the soundscape based upon the interpretation of the conceptual model with this rationale described below (Figure 9).

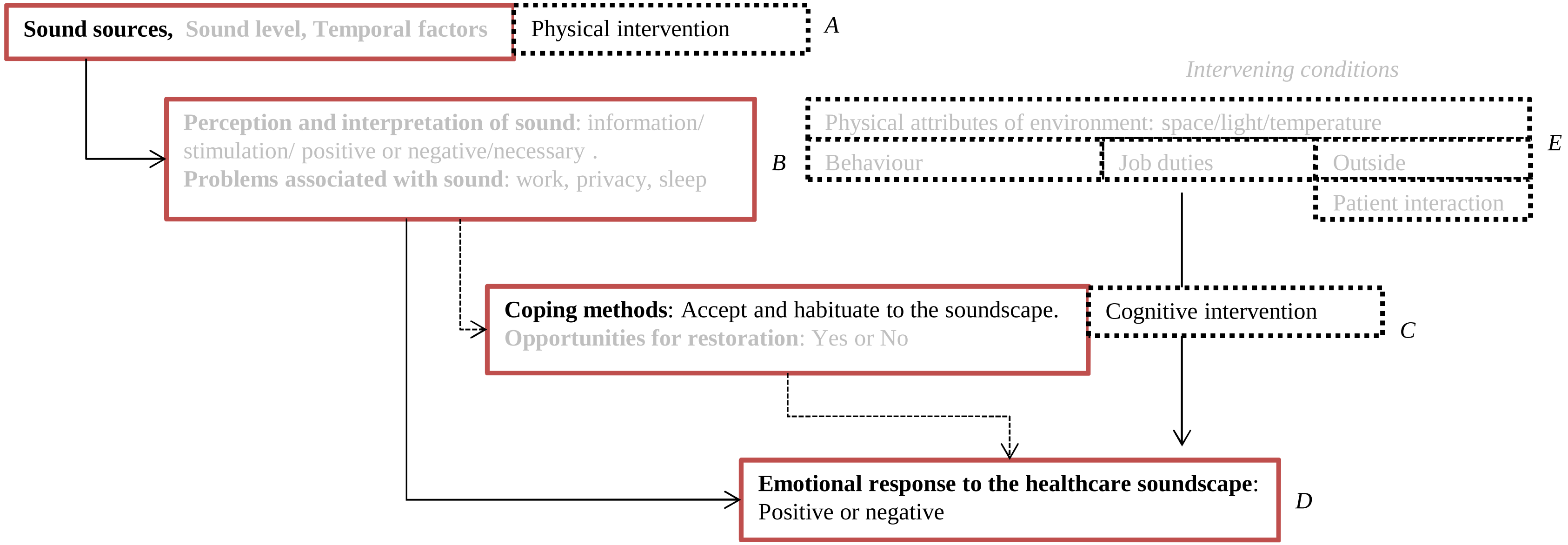


Figure 9. Elements of the conceptual model in the development of a rationale for further work to discover if physical and/or cognitive interventions produce a more positive emotional response

Firstly, physical sound sources may be manipulated and evaluated to test the effect on perception (natural or steady state sounds, relating to the positive comments of birdsong). Despite negative remarks about adding sound into the environment from patients, natural sound have been proven to elicit more positive feelings (Guastavino, 2006; Pheasant et al., 2010), thus their testing should be used. Secondly, a cognitive intervention can also be investigated. Providing information about the various sounds and their sources within the soundscape may be one way to create a more positive perception, as the interviews showed that people are more likely to accept a sound if it is understood. Support comes from Davies et al., (2013) in that psychological reactance is a term denoting how a perceived loss of control over the soundscape results in an individual's attempt to regain control. These can be behavioural or cognitive. Cognitive control means a reappraisal of a sound-(scape) including tolerance to unwanted sound. Yet curiously, no research exists looking at cognitive control strategies as an intervention in soundscape perception. Perhaps as most research looks at the addition of sound rather than the modification of perception.

Thus, information would influence the learning of the individual and the subsequent cognitive appraisal which drive emotional reaction towards a stimulus (Eysenck & Keane, 2000). This would test the important habituation effect derived from the interviews, along with the theoretical support from Truax (1984) in sound entering long term memory and Gleitman et al., (2004) demonstrating habituation to sound as a form of learning. Topf (2000) also advocates providing information to patients yet little empirical evidence supports this.

Testing such ideas using repeatable listening evaluations provided a robust way to evaluate the conceptual model’s themes and further develop the idea of what a positive ward soundscape is.

4.5. STUDY A2: OBJECTIVE SOUND ANALYSIS OF THE CT WARD SOUNDSCAPE

The purpose of this section of work was to acknowledge the acoustic aspect to sound in the environment. The aims were set out as:

- Capture and record the CT soundscape.
- Document the sound sources.
- Measure the acoustic attributes of the soundscape for contrast and comparison with literature.
- Collect sufficient recordings to allow a range of sound stimuli to be selected for the listening evaluations.

4.6. Procedure

In total 32 sound recordings were made within the CT ward during the one month data collection period. Each recording lasted a total of 5.10 minutes (310 seconds). This time period ensured that the broad character of the soundscape was captured and increase the chance of obtaining keynote sounds that mark a soundscape (Truax, 1984).

Recordings were made in six locations; within the main corridor, a male ward bay, the step-down area corridor and a male step-down bay (Figure 10). All recordings were made between 10am and 2pm dictated by the access allowed to the ward (table 8). After discussion with the ward manager, fewer recordings were made within the ward bays as it was felt that some patients may feel uncomfortable with the recordings taking place and to respect privacy.

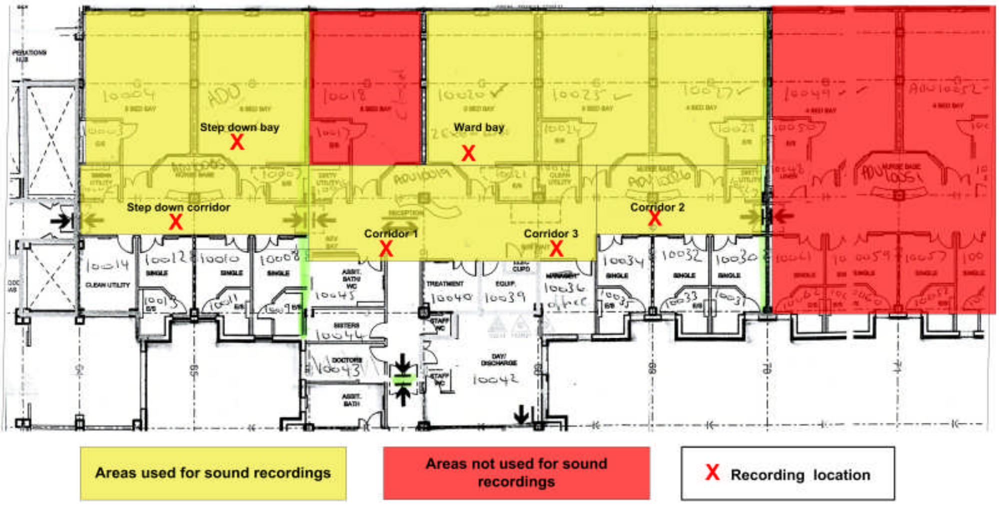


Figure 10. Layout of ward with markings of where recordings were taken.

Date of recording	**Recording location (abbreviation used to code recording)**	**Time of recording**
21.6.2010	Corridor 1 (L1) x2 Corridor 2 (L2) x2 Corridor 3 (L3) x2	11:00am-12:00pm
22.6.2010	Corridor 1 during lunch (L1 Lunch) x1 Corridor 1 during quiet time (L1 QT) x2 Corridor 2 during quiet time (L2 QT) x2 Corridor 3 during quiet time (L3 QT) x1	12:50pm-1:30pm
24.6.2010	Corridor 1 (L1) x2 Corridor 2 (L2) x1 Corridor 3 (L3) x2	11:00am-11:45am
28.6.2010	Corridor 1 during cleaning (L1 Cleaning) x1 Ward bay (WB) x2 Ward bay step down (WB SD) x2	10:30am-11:30am
29.6.2010	Ward bay (WB) x1 Ward bay step down (WB SD) x1	11:00am-12:00pm
8.7.2010	Corridor 1 (L1) x1 Corridor 2 (L2) x1 Corridor 3 (L3) x1	10:15am-11:15am

Table 8. Recording locations and time of recordings.

Recordings were made using a Bruel and Kjaer SonoScout Binaural recording device due to its unobtrusive and discrete size. The device uses microphones attached to each side of a headphone set worn by the researcher. This recorded the left and right channels, thus mimicking human hearing response. The device was calibrated, using a 98dB pure tone before the recordings were made. To create minimum disruption and obstruction recordings were made with the researcher standing with his back to the wall facing into the environment.

4.6.1. Analysis

The sound recordings were analysed using the Bruel and Kjaer SonoScout analysis software on a PC computer. All data was then converted to MS Excel format to enable further analysis. Cox (2010) suggests that sound quality metrics have been standardised, inferring the usefulness of a metric is dependent on the nature of the sound being tested. For this reason four metrics were chosen for the analysis, one physical measure, A-weighted sound pressure level and three psychoacoustic measures of loudness, sharpness and articulation index. Recordings from both left and right channels were sampled at around 0.05second intervals with left and right channels averaged in order to gain an overall value. Physical level (dBA) was calculated by using the average A-weighted sound pressure levels (Pascal, (PaA)) from both left and right channels and converting this value to the decibel ratings using the equation in Figure 11.

$$dBA = 20\log(\frac{PaA}{20\mu PaA})$$

Figure 11. Equation used to calculate the decibel rating of the sound recordings. *Note,* analysis software produced a Pa value A-weighted in order to calculate the dB A-weighted level.

The three psychoacoustic measures were defined as follows.

- Loudness, measured by the unit sone, is the perceptual measure on the energy content on the ear (Cox, 2010) and relates to the perception of loudness rather than the physical level. The higher the value the higher the perceived loudness of a sound.

- Sharpness, relating to pleasantness (Cox, 2010) of a sound, was chosen as Zwicker & Fastl (1999) suggest that sensory pleasantness depends mostly on sharpness. It is a measure of the high frequency content of a sound, the greater the proportion of high frequencies the ‘sharper’ the sound (Cox, 2010). Higher sharpness is related to unpleasantness.
- Intelligibility can be defined as how well speech can be heard. This was measured using the articulation index (AI) - a measure of how well speech can be heard. The measure is used in room acoustic design for predicting level or quality of speech communication within spaces (Bowman, 1974). An AI of 100 per cent means that all speech can be understood, and 0 per cent means no speech can be understood (Kim, Lee, & Lee, 2009).

Classification of sound sources used the coding procedure developed by Poxon et al., (2009) and involved the following steps:

- Listening to each recording to establish a coding schedule by marking down the sound sources (talking, footsteps, monitor beep et cetera.) within the recordings.
- Re-listening to each recording and noting the time these sounds occurred and their duration (to the nearest second).
- Creation of a timeline associated to metric values and sound sources for each 5 second interval within the recording. Each metric was averaged over the corresponding 5 second interval (0-5sec, 5-10sec et cetera) to give this value.

Once completed, frequency counts for the sources were made to assess the predominant sources of the soundscape. Basic descriptive statistics were used to assess each of the objective values; mean values (using a 95% average to increase the reliability by accounting for variation), standard deviation, minimum/maximum values, and range. Comparisons between the ward bay and corridor areas as well as quiet time and non-quiet time were made using a non-parametric Mann Whitney U-Test to account for the uneven number of recording from each location.

4.7. Results and discussion

4.7.1. Soundscape classification; coding schedule and frequency of sources

Five recordings were excluded due to interruptions being made to the researcher whilst the recording took place. The coding schedule (table 9) shows frequencies of each source within the recordings (Appendix 2.6). Frequency counts were used to show the composition of the soundscape. This revealed the majority came from human sounds (42.2%), concurring with comments from the interviews which included footsteps, talking of various degrees, along with general occupational duties (46%) including trolleys rattling, objects banging et cetera. Medical equipment made up smaller frequency (10.2%). However, because these events may be less frequent within the environment does not necessarily mean they do not influence the perception of the soundscape.

Source category	Sub source	Selection of descriptions	Percentage contribution of sound sources to the soundscape
Human	People Patients	Talking background, Footsteps Screaming, Coughing	42.2%
Occupational	Bin Cleaning Room Computer Curtains Door Draw Equipment File Floor Cleaner Phone Trolley Object Tap Wheel Chair	Opening/closing Sterilising machine Tapping Closing/opening Slamming, opening, closing Opening/closing Hissing, Squeaking Clip closing Polisher, Buffer Ringing Passing, Rattling Banging, Cups jingling, Dropping, Running water Moving (squeaking)	46%
Other	TV	TV sounds	1%
Medical	Monitors Equipment	Beeping, Fast beep High pitch beep, ripping sound	10.2%
External sounds	Car Alarm Car Passing	Alarm ringing Car passing hum	0.6%

Table 9. Soundscape coding schedule and percentage contrition of all sources from corridor and bay locations. *Note,* refer to Appendix 2.6 for complete schedule and frequency counts.

Sound sources within the bays differed minimally showing similar trends to the overall soundscape in source composition (table 10). Six recordings were made within the ward bays (four in the general bay areas and two in the step down area). For this reason frequency comparisons with corridor recordings are not directly comparable. However, it is of interest to note human sounds were most common which involved nurses interacting with patients, during observations. Occupational sounds within these areas included trolleys passing but also the sound of bins and cleaning, concurring with patients during the interview process. Unsurprisingly, medical sounds recorded higher frequencies than the corridors with beeping from monitor and alarm devices. This was expected as patients were extensively monitored. External sounds were noted with cars passing and car alarms (2 counts). Importantly, this showed the trend that human and occupational sounds sources dominate the soundscape.

Source category	**Source percentage contribution in corridor areas (%)**	**Source percentage contribution in ward bay areas (%)**
Human	43.3	38.7
Occupational	50.0	33.3
Medical equipment	1.3	25.3
Other	5.4	0
External sounds	0	2.7

Table 10. Sound sources for corridor and ward bay areas.

4.7.2. Between area differences

A Mann-Whitney U test was carried out to look for significant differences between the corridor and bay areas in the acoustic properties (table 11). A non-significant difference was found between the two areas (p=>.05) across all assessed metrics suggesting the two have very similar acoustic characteristics supporting the comparable source composition.

Location and Metric	**Min value**	**Max value**	**Mean$^{95\%ile**}$**	**Range**
Corridor*				
Sound level dB(A)	48.07	74.70	64.17	26.63
Loudness (sones)	6.02	32.78	17.51	26.76
Sharpness (accum)	1.05	1.90	1.582	0.85
Articulation Index (%)	15.86	94.37	82.22	78.51
Ward Bay*				
Sound level dB(A)	44.86	68.82	62.28	23.96
Loudness (sones)	4.32	22.49	15.47	18.17
Sharpness (accum)	1.20	1.98	1.629	0.78
Articulation Index (%)	32.70	98.62	86.73	65.92

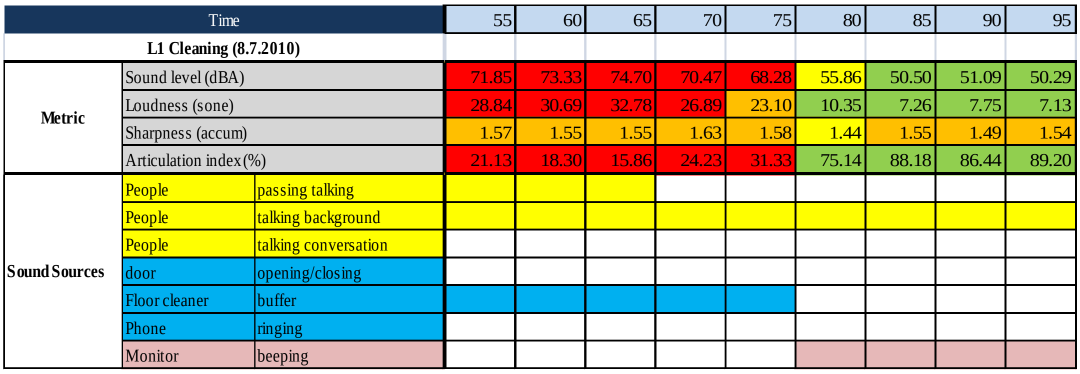
Table 11. Recorded metric attributes for each location in the ward. *Note*, * Non-significant difference between areas (based on mean values). *Note*,** All mean values represent the 95%ile value to increase the accuracy by including a greater range of the data.

4.7.3. Sound level (dB(A)) and Loudness (sones)

The majority of recording were taken within the corridor (L1,2,3). Across all corridor recordings the mean dB(A) was 64.17dB(A) with a range of 26.63dB(A) (see table 11). Sound level showed a significant strong positive correlation with loudness (r=0.975) (table 12). Within the bays there was also a similar range of sound levels (23.96dB(A)) the mean sound level was 62.28dB(A) with a peak of 68.82dB(A) - lower than the 74.70dB(A) recorded in the corridor. Again a strong correlation (r= 0.771) was seen between loudness level and sound level (table 12). Figure 12 shows how occupational sounds increase the sound level of the environment and cause high peak sounds, with relatively few sources present. However, when the sound of a cleaning machine stops associated metrics drop meaning the sound of a monitor is perceptible.

Metric	**Location**	**Sound Pressure Level (dB(A)) 95%**	**Loudness (sones)**	**Sharpness (accum)**	**Articulation Index (%)**
Sound Pressure Level (dB(A)) 95%	Corridor		.975**	.009	-.511*
	Bay		.771	-.486	-.943**
Loudness (sones)	Corridor	.975**		-.025	-.612**
	Bay	.771		.086	-.829*
Sharpness (accum)	Corridor	.009	-.025		.184
	Bay	-.486	.086		.429
Articulation Index (%)	Corridor	-.511*	-.612**	.184	
	Bay	-.943**	-.829*	.429	

Table 12. Correlation Coefficients. Note, ** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).



Time			55	60	65	70	75	80	85	90	95
L1 Cleaning (8.7.2010)											
Metric	Sound level (dBA)		71.85	73.33	74.70	70.47	68.28	55.86	50.50	51.09	50.29
	Loudness (sone)		28.84	30.69	32.78	26.89	23.10	10.35	7.26	7.75	7.13
	Sharpness (accum)		1.57	1.55	1.55	1.63	1.58	1.44	1.55	1.49	1.54
	Articulation index (%)		21.13	18.30	15.86	24.23	31.33	75.14	88.18	86.44	89.20
Sound Sources	People	passing talking	🟨	🟨	🟨						
	People	talking background	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨
	People	talking conversation									
	door	opening/closing									
	Floor cleaner	buffer	🟦	🟦	🟦	🟦	🟦				
	Phone	ringing									
	Monitor	beeping						▨	▨	▨	▨

Figure 12. Section of one recording demonstrating how a number of occupational sounds cause high metric and correspond to a more negative perception, observing the change at 75 seconds with reduced dB(A), loudness and an increase in AI. *Note,* green marks lowest 25% values, yellow lowest 25-50% values, orange highest 50-75% values, red highest 75-100% values. Key is the same for all similar figures.

4.7.4. Articulation index (AI)

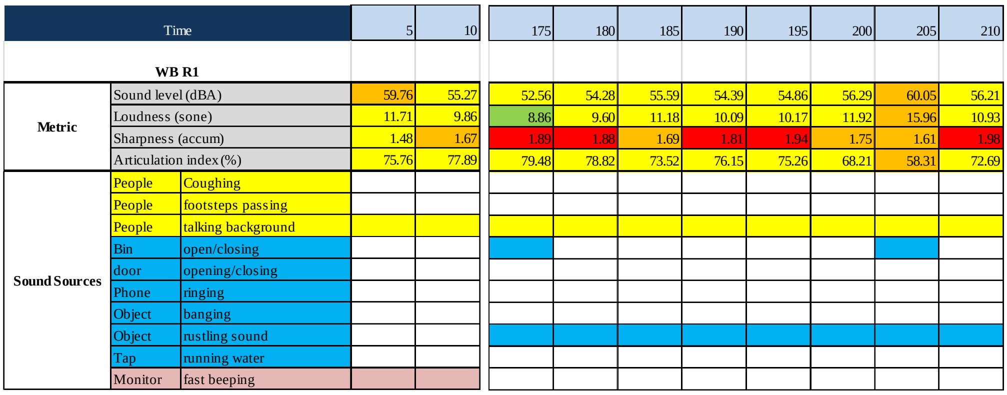
The AI showed a significant inverse relationship with sound level with correlations of, r=-0.511 and r=-0.943 for both corridor and bays respectively. Therefore, as sound level and the perception of loudness reduces, speech intelligibility of the area rises. Indeed, both areas recorded a large range in AI scores with the corridor having a mean of 82.22% and the bay area's recording 86.73%. This is reasonably high and relates to notions of verbal privacy being an issue. For instance, patients reflected on how high intelligibility can cause problems.

> *P: That's the only thing if you want a private conversation like when you are on the phones, you've got to speak to them normally and everybody's listening to what you are saying.*

The high range of values for the corridor and bay (78.51% and 65.92%) respectively suggest that sound events have a large impact on intelligibility concurring with nurses statements about the impact some occupational sounds have. It is also clear that intelligibility is better within the bay area associated with the lower sound level and loudness values.

4.7.5. Sharpness

Sharpness also provided a comparative metric showing the fluctuation of sound within the environment as there is little correlation with sound level (r=0.009, corridor, and r=-0.486, bay). Little difference in sharpness was recorded within the bays compared to that of the corridor; 1.98 accum vs. 1.91 accum respectively. There was a smaller range of variability in the values within the bay areas of 0.78 accum. These results denote the presence of some high pitch sounds such as alarm sounds. However, visualising the soundscape in Figure 13 it is clear that occupational sounds contribute to the sharpness of the soundscape possibly through squeaks in trolley movement. From the interviews, patients remarked that when medical devices were present they were accepted as long as they were actively applied whereas occupational and human sounds were more consistently cited as negative. Perhaps, this negative association is also related to the sharpness and thus their perceived pleasantness.



Time			5	10	175	180	185	190	195	200	205	210
WB R1												
Metric	Sound level (dBA)		59.76	55.27	52.56	54.28	55.59	54.39	54.86	56.29	60.05	56.21
	Loudness (sone)		11.71	9.86	8.86	9.60	11.18	10.09	10.17	11.92	15.96	10.93
	Sharpness (accum)		1.48	1.67	1.89	1.88	1.69	1.81	1.94	1.75	1.61	1.98
	Articulation index (%)		75.76	77.89	79.48	78.82	73.52	76.15	75.26	68.21	58.31	72.69
Sound Sources	People	Coughing										
	People	footsteps passing										
	People	talking background	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨
	Bin	open/closing			🟦						🟦	
	door	opening/closing										
	Phone	ringing										
	Object	banging										
	Object	rustling sound			🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
	Tap	running water										
	Monitor	fast beeping	▨	▨								

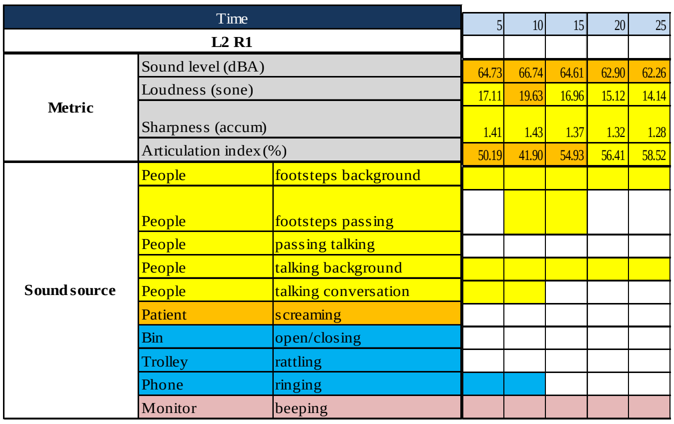
Figure 13. Section of sound recording showing how occupational sounds can increase sharpness in the soundscape above those of medical equipment.

4.7.6. Quiet time vs. non quiet time

A Mann Whitney U test showed a significant difference in sound level and loudness in the corridor locations during the quiet time period (*p=.035* and *p=.017* respectively). A non-significant difference was seen in the sharpness (*p=.482*) and AI (*p=.149*) possibly due to the continued sounding of medical equipment and monitors. This suggests that the frequency of trolleys and generally occupational sounds contributes most to sound level (Figure 14, 15). No ward bays were recorded during this time to acknowledge patient privacy. Importantly, these support the subjective views that quiet time has a beneficial effect which corresponds to a physical effect in reducing sound level and the perceived loudness of the ward.

Time			5	10	15	20	25
L2 QT2							
Metric	Sound level (dBA)		55.08	55.61	52.74	53.01	51.17
	Loudness (sone)		8.93	9.48	8.03	8.15	7.42
	Sharpness (accum)		1.30	1.28	1.30	1.31	1.38
	Articulation index (%)		81.61	78.66	85.99	85.48	87.85
Sound Sources	People	laughing					
	People	passing talking					
	People	talking background	🟨	🟨	🟨	🟨	🟨
	People	talking on phone					
	Patient	screaming					
	Patient	talking					
	Bin	open/closing					
	Phone	ringing					
	Object	banging					
	Monitor	beeping	🟥	🟥	🟥	🟥	🟥

Figure 14. Sound source and corresponding metric values during quiet time in location 2.



Time			5	10	15	20	25
L2 R1							
Metric	Sound level (dBA)		64.73	66.74	64.61	62.90	62.26
	Loudness (sone)		17.11	19.63	16.96	15.12	14.14
	Sharpness (accum)		1.41	1.43	1.37	1.32	1.28
	Articulation index (%)		50.19	41.90	54.93	56.41	58.52
Sound source	People	footsteps background	🟨	🟨	🟨	🟨	🟨
	People	footsteps passing		🟨	🟨		
	People	passing talking					
	People	talking background	🟨	🟨	🟨	🟨	🟨
	People	talking conversation	🟨	🟨			
	Patient	screaming					
	Bin	open/closing					
	Trolley	rattling					
	Phone	ringing	🟦	🟦			
	Monitor	beeping	🟥	🟥	🟥	🟥	🟥

Figure 15. Sound source and corresponding metrics during non-quiet time in location 2.

4.8. Conclusion from objective data

The coding scheme revealed a variety of different sound sources that concur with other work (Siebein & Skelton, 2009) in identifying sounds from outside, medical equipment, conversational sounds, and occupational sounds. Therefore, healthcare soundscapes appear to contain the same sound attributes across spaces. Juang et al., (2010) found, through questionnaires, nurses reported the major noise sources to be talking of patients and family members, shouting of nursing staff, rolling trolley wheels, children playing. Also, 50% of patients and visitors considered doors closing/opening and patients moaning or crying to be the major noise causes inside the ward (Juang et al., 2010) suggesting occupational and human sounds are dominant thereby supporting these findings.

Regarding sound level, Akansel & Kaymakci (2008) reported that sound levels ranged from 49-89dB(A) with a mean of 65dB(A) within a coronary care ward. The presented results recorded a peak of 74.70dB(A) with a combined mean from the corridors and bays of 63.50dB(A). These concur with the recent studies of Pope (2010) & Juang et al., (2010) who reported mean sound levels to be 63 dB and between 52.6-64.6 dB respectively, although not A-weighted. This again supports a degree of generalisation across healthcare spaces meaning demographic characteristics are the largest variable. Therefore, arguably it is the perception needs to be measured to understand these positive and negative aspects before the objective aspects should be altered.

The use of psychoacoustics provided an alternative approach to look at the hospital soundscape. AI had strong inverse correlation with loudness (corridor: r=-0.612/ bay: r=-0.829) allowing suggestions to be made regarding the impact of loudness. As loudness increases this will impact the individual more greatly, in terms of their ability to communicate. When considering some of the comments from the nursing staff this is reinforced:

> *N: The hoover doesn't bother me but the buffer does. That's a nightmare, especially when you're trying to deal with telephone calls…if I'm on the phone or dealing with something important I will say turn that off for a minute.*

Medical equipment sounds were thought to contribute to the sharpness within the soundscape and therefore affect the sense of pleasantness. However, occupational sounds appear to contribute through squeaks, doors slamming, bins closing among others which may be perceived most negative. Again, this supports the comments from the interviews in that occupational sounds, floor cleaning buffer, trolleys et cetera were most negative.

This is highlighted by Figure16, which depicts the soundscape during the moment where a patient was screaming. A patient freely expressed their concern during the interviews when hearing this. However the objective levels are low (the lowest 50% from all those obtained) but the sounds create a strong negative emotional response not captured through these objective measures. It is the *subjective response* that is important.

Time			30	35
L2 QT2				
Metric	Sound level (dBA)		56.28	58.32
	Loudness (sone)		9.64	10.65
	Sharpness (accum)		1.25	1.24
	Articulation index (%)		79.48	75.60
Sound Sources	People	laughing		
	People	passing talking		
	People	talking background	🟨	🟨
	People	talking on phone		
	Patient	screaming	🟧	🟧
	Patient	talking		
	Bin	open/closing		
	Phone	ringing		
	Object	banging		
	Monitor	beeping	🟥	🟥

Figure 16. Source and metric coding showing the limitations of relying on metric coding due to response elicited by patient screaming.

These objective findings link to the conceptual model described in section 4.3. Usefully, the model can depict the components that influence the perception of the soundscape and it is possible to map the influence of quiet time on the individual based on the results (Figure 17). When quiet time is present, there are reduced sound sources resulting in a lower sound level and resulted in a calmer perception and emotional response. Occupational and human sounds are habituated to as they form the dominant aspects of the soundscape. Therefore, when these are present patients and nurses habituate – accepting the soundscape. When these are controlled, through quiet time, habituation is not necessary therefore producing a more positive response.

This started to validate the model in terms of its ability to show what influences of perception and begins to show the habitual effect of the soundscape. The results here link the objective components and the subjective notions of the soundscape in a more theoretical manner, acknowledging that they are not necessarily mutually exclusive but exist together. This can be done formally by linking the objective data gathered from the ward described in the next section to expand the conceptual model in a more complete way.

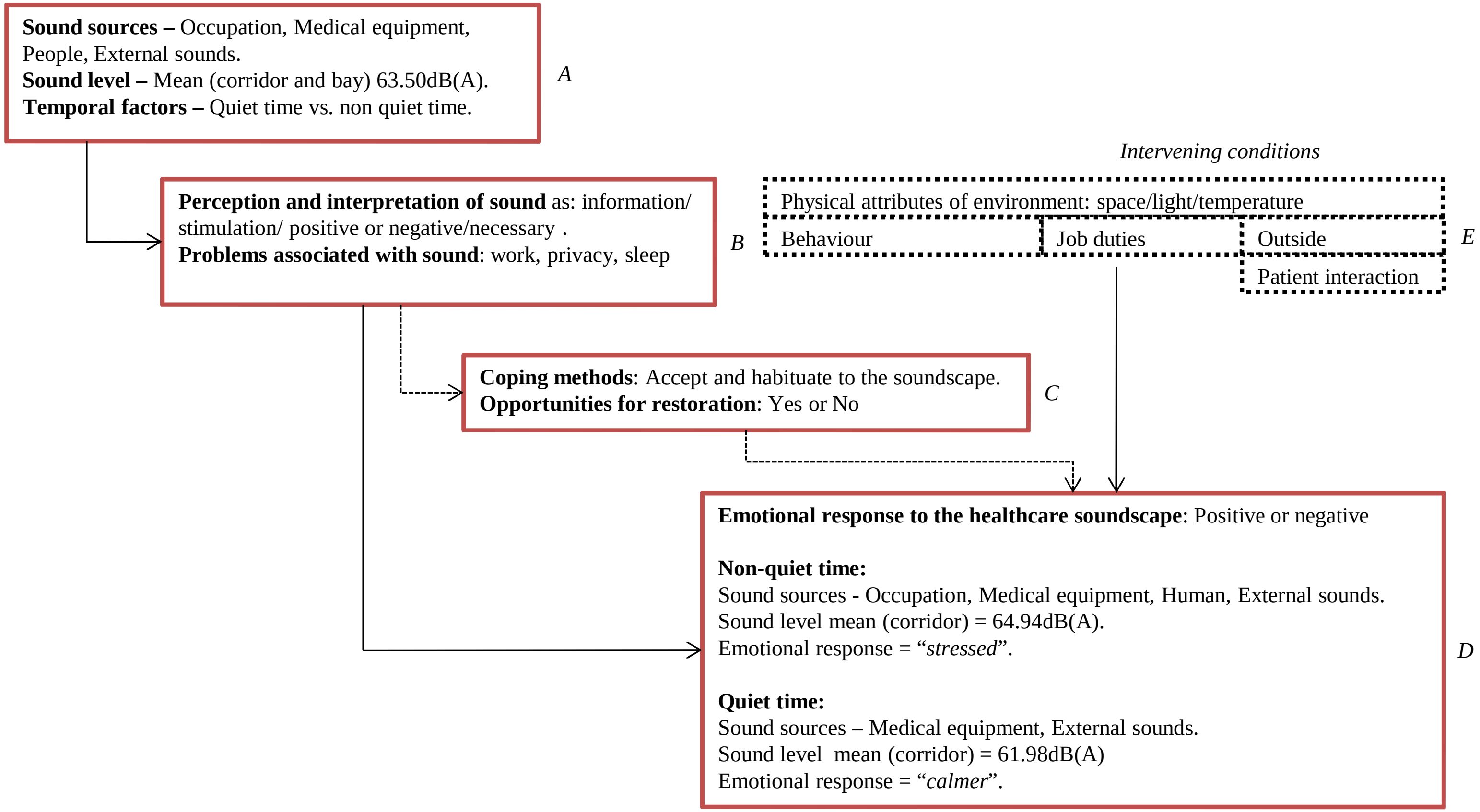


Figure 17. Conceptual model of a hospital ward soundscape perception with the addition of objective data enabling deeper understanding of perception using quiet time as an example.

4.8.1. Study limitations

Limitations are acknowledged in study A1.

- Only nurse perspectives were obtained therefore limiting the generalisation across healthcare professionals. However, the concurrence with similar studies (Xie & Kang, 2010; Rice, 2003; Waye et al., 2010) containing a broader sample go some way to assist in validating the presented results.
- Secondly, the patient sample had a mean age of 68.7 years meaning that the views expressed in the interview may not be valid for younger patients. However, within the context of a CT ward this is a representative sample age. Theoretical saturation was obtained in both groups, providing a valid set of findings upon which to base the further work of the project.
- The presence of the researcher also may have influenced the results:

  > *N:* ***(And do you notice sound with the activities that are going on?)*** *Not until the other day when I noticed you doing that [recording sounds].*

  Although no observations of the staff were specifically taken there may have been some observer reactivity whereby, the presence of the observer can lead to people changing their behaviour (Shaughnessy, Zechmeister & Zechmeister, 2009, p, 124). As a result some responses in the interviews may have been changed to be more acceptable. However, the fact that theoretical saturation was met suggests such effects may have been limited as cohort trends were discovered in the data. Furthermore, the objective analysis showed that SPL dB(A) was comparable to previous research meaning that any behaviour change did not influence the soundscape greatly.

The objective analysis of the soundscape, study A2, has the following limitations:

- The prominence of the sources in the recordings could not be determined. Therefore, a sound may have been present in the background and noted but its relative appearance compared to a foreground sound is unknown. This spatial aspect is something that the metrics and coding cannot account for but should be acknowledged in interpretation of the findings and this may have a bearing on the perceptual response.
- A further limitation falls within establishing the period that sound events occur. This was done by ear and was only feasibly possible to do to the nearest second. A more accurate timeline of events would be established if the sampling rate could be improved. However, the analysis is used as a visual representation of the sound sources across time, which proved to be accurate enough. Indeed, many of the key fluctuations in metric values line up with sound events which suggest that the method holds a degree of validity.
- This study was only one part of the assessment of the CT soundscape. More focus was emphasised on the interview study. As a result the methodological process to capture the objective data was not as robust as it might have been in terms of the process and timings of recordings. Despite this however, a large number of recordings were captured in a repeatable manner. Consequently, these should be reflected as reasonably accurate considering the agreement with literature.

4.9. Concluding remarks from Chapter 4

Both study A1 and A2 of this chapter provided an understanding of the soundscape within the CT ward. Part A showed the subjective experience whilst Part B revealed that the acoustic attributes were comparable to much of the literature cited in Chapter 2. The results provided a robust way to select sound clips for listening evaluations based upon objective values and key content. The next stage was to carry out listening evaluations to further understand perception. This utilised the findings here in a constructive way to assist in developing potential soundscape interventions to improve and manage the perception of the CT ward soundscape highlighted in figure 9.

CHAPTER 5

PART B: UNDERSTANDING PERCEPTION USING LISTENING EVALUATIONS

5.0. Introduction

Listening evaluations are a way for participants to rate subjective responses to sounds in a controlled environment. The main aim of this section of work was to define perception in a simple manner and create a perceptual space to measure the effectiveness of soundscape interventions. Indeed, as Cain et al., (2013) state that to consider the psychological effects of the sound environment, a more qualitative description may be appropriate. This chapter describes two studies used to define this perceptual space representing the subjective response to hearing the CT soundscape. The aims of the study were as follows:

- To establish if the listening evaluation method yielded valid results from participants.
- Capture language from participants which represented how they felt from hearing the CT soundscape. Compare this to the language obtained in Chapter 4.
- Use the semantics obtained in Chapter 4 Part A to develop a questionnaire to rate the subjective response to the CT soundscape.
- Use the questionnaire the rate the CT sound clips and conduct Principal Component Analysis on the results to form a perceptual space.

5.1. Experimental set up

5.1.1. Sound stimuli selection

In order to assess perception, the soundscape of the CT ward needed to be presented to participants. A total of 19 sound clips were used in the evaluation (table 13), selected from the analysis of the recordings in Chapter 4 Study A2. The sound clips contained a broad range of dominant features using Axelsson et al., (2010) definition of dominance as *"a category of sounds in the foreground and not to a* *single sound event”*. These also included a range of sound levels. Three clips were manipulated with the addition natural sounds using bird song, a stream, along with a steady state sound to encourage a broad range of responses. These sounds were digitally mixed into the sound clips using Nuendo 4 sound editing software to form a congruent background addition. Sound clip details and associated playback sound level are listed in table 13.

Clip Number	**Recorded dB(A) 95%ile mean over clip period**	**Playback dB(A) 95%ile mean over clip period**	**Difference dB(A)**	**Clip Content**
1 (*practice and repeated at end)*	68.77	72.31	3.54	People talking and sterilising machine starting and continuing masking other sounds.
2	56.25	65.78	9.53	Talking and footsteps in background. Doors opening and closing with object banging.
3	61.07	74.21	13.14	Talking in foreground and footsteps in background. Cups jingling.
4	56.09	63.24	7.15	Talking and footsteps in background. Trolley passing, doors opening and closing, monitor beeps in background.
5	52.40	64.67	12.27	Quiet corridor. Monitor beeping sounds in background.
6	62.19	68.20	6.01	Deep rumble of a passing trolley. Some background talking.
7	61.37	68.03	6.66	Talking and footsteps in background. Patients screaming intermittently, trolley passing.
8	60.19	63.78	3.59	Talking and footsteps in background. Trolley passing.
9	60.19	67.56	7.37	Talking in foreground from nurse taking patient observations, monitor beeping, and car passing in background
10	62.94	70.56	7.61	Talking from nurse taking observations and patient talking in foreground, monitor beeping.
11	48.03	62.34	14.31	Quiet ward with private conversation between nurse and patient in foreground.
12	54.66	65.43	10.78	Quiet ward with beeps rustling and talking in background.
13	63.42	69.64	6.22	Rustling of bins being changed in ward bay, water running, and background talking.
14	55.52	59.72	4.20	Floor buffer, long beeping. Monitor beeps. Soft talking in background.
15	61.81	76.80	14.99	Monitor beeps (various) background talking from nurse to patient. Occupational sounds in background.
16	65.43	68.75	3.31	Nurses talking loudly and laughing. Monitor beeps, floor buffer in background.
17	52.40	64.67	12.27	Quiet corridor. Objects banging in background. Sound of a stream added.
18	56.43	70.16	13.74	Quiet corridor. Objects banging in background. Sound of a stream added.
19	52.40	64.67	12.27	Quiet bay with monitor beeps. Slight background sounds. Sound of bird song added.

Table 13. Sound clip details including playback dB(A) level vs. recorded and clip content. *Note,* dB(A) taken as a 95% average.

5.1.2. Sound Room laboratory and set up

Listening evaluations were held in a Sound Room laboratory. This consisted of a 16 speaker system run through a PC computer using Nuendo 4 sound editing software to play the sound stimuli (Figure 18). The system played back the binaural hospital recordings through all 16 speakers. The recordings were not normalised for sound level but were set as close as possible to the level which were originally recorded at from the hospital. This was to replicate the variation in sound level found within the ward. Analysis could then be used to assess if correlations between perception and sound level existed. Sound level (dB(A)) was recorded as a 95 per cent average over clip length to increase accuracy and account for variation in level within the clip. To accurately carry out this the following process was developed.

- Playing each sound clip recording.
- Recording the evaluation using Bruel & Kjaer binaural sono-scout recording device whilst sitting in the evaluation chair (Figure 1).
- Download the measured sound levels on to Bruel & Kajer sono-scout analysis software.
- Calculate the dB(A) value of each clip (see chapter 4 Figure 11 for equation).
- Adjust the sound level of each clip as required within Nuendo 4 sound editing software and repeat the procedure if need.

Figure 18. Sound room laboratory and speaker set up. *Note*, three images used to create photograph hence slight distortion.

5.1.3. Research ethics

The University of Warwick Biomedical Research Ethics Committee reviewed the study for its ethical merit and granted approval before any evaluations took place.

5.2. STUDY B1: CAPTURING SEMANTICS DESCRIBING THE EMOTIONAL RESPONSE TO THE CARDIO-THORACIC WARD SOUNDSCAPE

5.2.1. Aim

The aim of study B1 was to gather key semantics that captured how individuals felt when exposed to the CT soundscape and specifically looked:

- To compare the semantics collected from the interview study with the listening evaluation to see if language was concurrent.
- Collect semantics to create semantic rating scales used to define a perceptual space.

5.2.2. Procedure

The procedure used to conduct the listening evaluation is outlined below:

- Each participant read the information sheet detailing the study and signed the consent form (Appendix 3.1.).
- A verbal description read from a prewritten script of what the participant was required to do was given to maintain consistency.
- Participants were asked to read the instructions and raise any questions.
- Participants were seated in a single chair, positioned in the centre of the sound room (Figure 18). The lights were dimmed to increase the immersion within the environment. Once participants were clear on the process the evaluation started.
- A practice evaluation of one sound clip was carried out. This clip was repeated at the end of procedure to include in the analysis (refer to table 13). The evaluation then followed.

- Each sound clip was presented for around 20 seconds followed by a 20 second inter stimulus period thereby allowing participants to discriminate between clips. During this 40 second period participants were asked to imagine sleeping, reading, talking to a relative or on the ward in a hospital and then to write adjectives based on the question: *"Listen to the recording. How does it make you feel?"* (Appendix 3.2.). These scenarios were derived from observational data obtained by noting the activities of patients and nursing staff within the CT ward during the interview study detailed in Chapter 4. Scenarios assisted participants in imagining the hospital ward and how sound may affect them.
- At the end of the evaluation participants filled in basic demographic data and comments to aid interpretation.

To ensure that the recordings were presented in no particular order a Latin square randomisation method was used to counterbalance the play order of the 19 sound clips (Appendix 3.3.).

5.2.3. Sample

As discussed in section 3.2.5, convenience sampling was used for the evaluation stage of the research. A total of 18 participants were recruited for the study with a mean age of 35 (S.D. 12.4) years. Eleven of the participants were male with the remaining seven female. The sample contained a broad range of demographics from the university community. Two participants, both female, were healthcare professionals. The sample size was determined by saturation of semantics in the analysis. This was defined by no new semantics being frequently obtained. Once this was met no new participants were recruited. All participants reported normal hearing but due to the variation in age, natural auditory sensitivity may have been different.

5.2.4. Analysis

Each questionnaire was analysed by listing the various semantics participants used. This was done after each evaluation to determine when saturation had been met. Semantics were then grouped into positive and negative cohorts along with words/phrases which were neutral/unclassified. Frequency counts were used to extract the dominantly used words.

5.3. Results

The listening evaluation yielded a cumulative total of 714 semantics. These were split between positive (178), negative (348), and neutral/unclassified (188) semantics. In order to count the frequency of words and reduce the data, variations of the tense of the same word were used in the frequency count of that adjective. For example, if ‘calmer’ was written this was included in the frequency count for the word ‘calm’. This reduced the total amount of different semantics captured. The result of the reduction is listed in table 14.

Positive semantics	**Listening evaluation frequency (n=18)**	**Combined frequency with interview study (n=45)**	**Negative semantics**	**Listening evaluation frequency (n=18)**	**Combined frequency with interview study (n=45)**
Calm	52	63	Annoyed	52	60
Relaxed	16	26	Distracted	41	41
At ease	10	10	Irritated	19	22
Reassured	14	15	Frustrated	18	20
Peaceful	6	9	Disturbed	17	19
Comfortable	7	9	Stressed	9	17
Intrigued	9	9	Uncomfortable	16	17
Curious	7	7	Worried	15	15
Alert	6	7	Anxious	13	13
Happy	6	6	Concerned	13	13
Reflective	1	1	Angry	11	11
			Confused	7	7
			Bored	3	3

Table 14 .Frequency counts of semantics obtained from listening evaluations and interview study

5.3.1. Semantics

A total of 45 different positive semantics were obtained. Of these, the most frequently reported semantics was ‘calm’ followed by ‘relaxed’, ‘reassured’, ‘at ease’, ‘intrigued’, ‘peaceful’, ‘comfortable’, ‘curious’, ‘alert’, and ‘happy’. Although ‘Ok’ was frequently responded, it was decided this describes a neutral response and therefore, was not used in clustering of positive words (table 14). Seventy nine negative semantics were obtained. The most commonly described feelings were ‘annoyed’, ‘distracted’, ‘irritated’, ‘frustrated’, ‘disturbed’, ‘stressed’, ‘uncomfortable’, ‘worried’, ‘anxious’, and ‘concerned’ (table 14). In order to ensure that an accurate array of language had been obtained it was necessary to integrate the findings with the interviews (table 14) discussed in Chapter 4. In total the array of semantics captured are formed from a sample of 45 participants from the listening evaluation and the interviews. Importantly, this showed concurrence between the two data sources.

A large array of other semantics could not be classified, 146 in total. Often these had a frequency count of one and therefore did not describe dominant feelings and so were not considered further. The most frequent semantics from this group were ‘Ok’, ‘normal’ and ‘neutral’. As remarked above, these do not describe an emotional response rather the absence of it.

5.3.2. Conclusions from the validation process

The results showed semantic similarity between the evaluation and the interview data. Therefore in the listening evaluation procedure, the CT ward sound clips elicited similar perceptual responses as individuals within CT ward. It was concluded this was a valid way to investigate the perceptual response to the CT soundscape. Most importantly, the results allowed a semantic perceptual space to be created with use of PCA to extract the key dimensions which describe a person’s response to the CT hospital ward soundscape. This is described below.

5.4. STUDY B2: CREATING A PERCEPTUAL SPACE USING PCA.

The aim of this study was to establish a perceptual space which defined the response to hearing the CT soundscape. Furthermore, this would then be able to be used to map soundscape interventions similar to Cain et al., (2011). It is not uncommon for perceptual spaces to be used when investigating the response to environmental stimuli (Axelsson et al., 2010; Russell, 1980). The response was defined as an ‘emotion’. The term ‘emotion’ was chosen as the semantics obtained from Study A1 predominantly described feelings. As such, ‘emotion’ was defined by the language that described a feeling (for example, calm-agitated) elicited by the soundscape not the description of the soundscape itself (for example, hard-soft). Therefore, specific aims included:

- Creating semantic scale to represent the emotional response to the CT soundscape.
- Define a perceptual space representing the response to the CT soundscape.
- Understand the reliability of the dimensions creating the space
- Visually assess the response to the CT soundscape on the perceptual space.

5.4.1. Experimental Design

5.4.2. Semantic differential technique and semantic selection.

In order to establish the perceptual space it was necessary to decide on a method with which to create a questionnaire which allowed the perceptual response to the CT soundscape to be rated. As such, a semantic differential technique was chosen as the questionnaire format.

Semantic differential analysis attempts to transfer subjective meaning into a quantitative measurement (Osgood et al., 1957) thereby lending itself to the quantitative PCA method. Moreover, this technique has been utilised in both soundscape and sound quality research (Kang & Zhang, 2010; Raimbault et al., 2003; Chouard & Hempel, 1999; Cain et al., 2013) providing support to utilise the technique here. Indeed, the semantic differential technique is valuable for identifying the psychological dimensions along which concepts or sensory stimuli that are evaluated (Kidd & Watson, 2003). Semantic differential is distinct from a Likert scale as it is concerned with assessing the subjective *meaning* of a concept to the person rather than assessing how much the person believes *in* that concept (Robson, 2002, p, 299). Here this refers to the meaning of the soundscape.

The principle behind this approach is that the perception of a stimulus falls into different dimensions, each defined by a linear semantic space with extremities defined by two bipolar adjectives (Jennings et al., 2010), see table 15. This space is a region of some unknown dimensionality (Osgood et al., 1957). It can be assumed in the application here, the space refers to the subjective response to the soundscape, and thus use of semantic differential analysis builds a perceptual space which defines the emotional response based upon these key semantics. The scale therefore reflects the perceived level of each of the adjectives (Jennings et al., 2010).

Osgood et al., (1957) suggest that how a person behaves in a situation depends upon what that situation means or signifies to them, remarking that semantic variables can be conceptual in nature and indexed quantitatively. Therefore Osgood et al., (1957) advocates using a 7 point scale to rate the semantics scales as the terms extremely, quite, slightly – applied to each numeral - have equal value of intensity of whatever representation the semantics elicit (see table 15).

The size of rating scale has been shown to have influences on the results of the technique. Preston & Colman (2000) looked at the effect of different scale sizes based on a self-administered questionnaire rating service elements on a recently visited store or restaurant. Using scale sized of 2-11 rated from very poor to very good, scales with 10, 9 and 7 points were most preferred. The most reliable scales were between 7-10 points and the most valid and discriminating were those with 6 or more anchor points. Importantly, the results suggest rating scales with 7, 9 or 10 response categories are to be generally preferred (Preston & Colman, 2000), although the authors suggest that the context of the scale will have a bearing. Using the conclusions of both Preston & Colman (2000) and Osgood et al (1957), a 7 point scale was chosen as it offered a balance in terms of reliability and discriminating power.

	Semantic Scale		
1	Calm	1 2 3 4 5 6 7	Agitated
2	Relaxed	1 2 3 4 5 6 7	Stressed
3	Reassured	1 2 3 4 5 6 7	Worried
4	At ease	1 2 3 4 5 6 7	Anxious
5	Intrigued	1 2 3 4 5 6 7	Bored
6	Comfortable	1 2 3 4 5 6 7	Uncomfortable
7	Curious	1 2 3 4 5 6 7	Apathetic
8	Alert	1 2 3 4 5 6 7	Unprepared
9	Annoyed	1 2 3 4 5 6 7	Content
10	Peaceful	1 2 3 4 5 6 7	Troubled
11	Attentive	1 2 3 4 5 6 7	Distracted
12	Tolerant	1 2 3 4 5 6 7	Irritated
13	Satisfied	1 2 3 4 5 6 7	Frustrated
14	Undisturbed	1 2 3 4 5 6 7	Disturbed
15	Unconcerned	1 2 3 4 5 6 7	Concerned

Table 15. Semantic scales used in evaluation.

5.4.3. Development of questionnaire format

After these theoretical underpinnings were established, a pilot questionnaire format was produced. In order to develop robust semantic scales it was necessary to match the positive and negative semantics gathered from part A into semantic pairs accurately. Kansei engineering, described in section 3.2.2, has used the technique as this is a psychological phenomenon for measuring and developing products (Ishihara, 2010, p, 31). Ishihara (2010) modified the original semantic differential technique advocating the use of denial words such as beautiful-not beautiful instead of antonyms. The author comments that the difference in meaning (for example, beautiful-ugly) can lead to skewed data preventing statistical analysis and, to ensure that the meaning of the words is fully understood, denial words should be used (for example, beautiful-not beautiful). A pilot study was performed with three participants to assess the usability of this style of semantic differential technique.

5.4.4. Modifications after pilot questionnaire format

Using the questionnaire format described in section 5.4.3 the pilot evaluation showed it was difficult for participants to understand and interpret the questionnaire when using Ishihara's (2010) denial word theory (Appendix 3.4.). Due to absence of bipolar anchors the denial scale did not show an extreme in emotion. For example, on the scale 'calm-not calm' the notion of 'not calm' appeared to refer to a neutral feeling rather than an opposing feeling. Therefore, participants found it hard to rate the magnitude of meaning. Secondly, scales were also duplicated as 'calm-not calm' and agitated-not agitated' appeared to measure the same as a 'calm-agitated' semantic scale.

For this reason the original semantic differential procedure of Osgood et al., (1957) was used which produced a more consistent, concise, and understandable format. Fifteen semantic scales were made from the results of Study B1. The scales were constructed based on the most frequently reported lexicons and paired according to meaning (table 15). Where this was not possible, assessment of previous soundscape and sound quality research was used to find suitable alternative along within the Oxford English Dictionary (2005) (Appendix 3.5. and 3.6.). As discussed above, a 7-point rating scale was used. Thus, the numerical values of each point on the scale was defined by the notions extremely, quite, slightly either side of the neutral point 4 on the scale.

5.4.6. Reliability of questionnaire design

It was important to consider the trustworthiness of the format once developed. The semantic differential technique holds benefits in terms of scale reliability**.** Indeed, Coolican (1990) cites Osgood et al., (1957) that the technique possesses good reliability and correlates with other attitude scales thus providing concurrent validity. A weakness to the technique is response bias where individuals habitually mark at the extremes of each scale without considering stronger or weaker responses as points lack verbal distinction of Likert scales (Coolican, 1990).

However, the technique avoids the systematic effect of pseudoneglect , the attentional bias to the left or right hand side of the scale (Nicholls et al., 2006), seen in Likert scale because of the presence of bipolar anchors. The method additionally reduces the chance of acquiescence bias (Friborg et al., 2006), always responding positively to answers, again, as the scale has opposing words. Additionally, scale order and presentation format may influence responses. Wegner & Fabrigar (2004) suggests not confusing respondents by intermingling different variables, for example, altering the presentation order of the scales throughout the questionnaire. Maintaining the presentation order of scale items throughout each page of the response sheet was decided to reduce the confusion for participants, keeping positive responses on the left with negative on the right. This also enabled the assessment of any acquiescence or pseudoneglect bias throughout the response sheet. Half way through the sample (n=16-30) the scales were reversed so negative words appeared on the left and positive on the right to counteract any potential for bias in the results. In order to ensure the scales appeared in no particular order a Latin square method was used to randomise the order the 15 semantic scales (Appendix 3.7.). The final questionnaire format is shown in Figure 19.

I Feel								
Calm	1	2	3	4	5	6	7	**Agitated**
Comfortable	1	2	3	4	5	6	7	**Uncomfortable**
Attentive	1	2	3	4	5	6	7	**Distracted**
I Feel								
Relaxed	1	2	3	4	5	6	7	**Stressed**
Curious	1	2	3	4	5	6	7	**Apathetic**
Tolerant	1	2	3	4	5	6	7	**Irritated**
I Feel								
Reassured	1	2	3	4	5	6	7	**Worried**
Alert	1	2	3	4	5	6	7	**Unprepared**
Satisfied	1	2	3	4	5	6	7	**Frustrated**
I Feel								
At ease	1	2	3	4	5	6	7	**Anxious**
Peaceful	1	2	3	4	5	6	7	**Troubled**
Undisturbed	1	2	3	4	5	6	7	**Disturbed**
I Feel								
Intrigued	1	2	3	4	5	6	7	**Bored**
Content	1	2	3	4	5	6	7	**Annoyed**
Unconcerned	1	2	3	4	5	6	7	**Concerned**

Figure 19. The developed semantic differential questionnaire with a 7 point rating scale using the terms extremely, quite, slightly, applied to numbers either side of 4.

5.5. Method

5.5.1. Procedure

The same 19 sound recordings and procedure was used as described in Study B1 but with the removal of scenarios (Appendix 3.8.). Each sound clip was repeated four times resulting in the total stimulus being presented for 80 seconds. This was then followed by a 20 second inter stimulus period to allow any remaining scales to be rated and differentiate between clips. The total evaluation length was around 40 minutes.

5.5.2. Analysis

The results were analysed using PCA as this is most useful when the aim is to reduce a relatively large number of variables to a smaller number but still capture the same information (Leech et al., 2008). This was used to reduce the number of semantic pairs down to the principle scales that define the perceptual space defining the response to the CT soundscape. Osgood et al., (1957) suggest that factor analysis should be used to define the semantics space with maximum efficiency which exhausts the dimensionality of the space. PCA is similar to factor analysis however, factor analysis postulates that there is a smaller set of unobserved (latent) variables or constructs that underlie the variables measured. PCA is simply trying to mathematically derive fewer variables to provide the same information that one would obtain from a large set of variables (Leech et al., 2008). As the variables were derived from studies considering the response to the CT soundscape it was not necessary to explore any potential 'latent' concepts behind them. It could be argued that this is a more robust way to cluster scales into semantic dimensions because it is based upon the principal components and the calculated factor loadings each scale has to for each component. An orthogonal rotational factor model (varimax) was used to form a perceptual space enabling the variables to be represented visually and thus producing the desired perceptual space. This would map the response to the soundscape and ultimately, potential interventions.

The assessment of correlation coefficients was used to show the conceptual overlap of words in the extracted dimensions, that is, those that describe similar states as in Russell (1980). When defining a circumplex model of affect, Russell (1980) uses the example that subjects who checked "happy" also checked "delight" not because they are two separate events but because they describe the same state.

Therefore correlation data was used to show the overlapping of scales, revealing the definition/meaning behind them as participants interpreted it. This allowed the CT ward soundscape to be described in a reduced manner by the principal components and key semantics scales representing these based upon factor loadings and the correlations. Analysis was performed using SPSS 19 with any missing data replaced with the variable mean.

5.5.3. Sample

When using PCA methods, a ratio method of sample size calculation is applied. Brace et al., (2006) suggest that there should be more participants to variables and cite (Kline, 1994) to suggests that a minimum ratio of 2:1 should be used. Using this sample size was calculated as follows:

Sample size (n) = 15 variables (scales) x 2 = 30

Sample size was checked before analysis using Kaiser-Meyer-Olkinn (KMO) measure of sample adequacy to see if more participants were required to obtain a reliable solution.

The sample consisted of four healthcare professionals (two physiotherapists, a research nurse and intensive care sister) and 26 members of the public from within and outside the university community. There was an even gender split with 15 male and 15 female participants with a mean age of 35yrs (S.D. 12.4) with 20 participants experiencing a hospital environment within the year. Again, convenience sampling was used utilising known contacts and willing participants.

5.6. Results

The data showed a normal distribution on all scales (Appendix 3.9.) and PCA was conducted on the 15 semantic scales with an orthogonal (varimax) rotation applied. KMO measure verified the sampling adequacy of the test, KMO = .94

(superb according to Field, 2009) and all KMO individual values >.71 (above the acceptable limit of .5 (Field, 2009)). Therefore the sample size was adequate despite being relatively small. Bartlett's Test of Sphericity x^2 (105) = 7344.25, p = <.001, indicated that correlations between the semantic items were sufficiently large for PCA.

5.6.1. PCA

The analysis revealed a two dimensional model representing the perceptual dimension of the CT soundscape. Components 1 and 2 explained 56.8% and 13.2% of the variance within the data, respectively. This represented 70.1% of the total variation within the results. The extracted factors were based upon meeting Kaiser’s criterion of eigenvalue = > 1.0. Figure 20 shows a clear point of inflexion, supporting this extraction. A three component factor was requested to understand if a third component was present. This variable accounted for 5.8% of the variance within the data set therefore was excluded from interpretation as it did not meet the eigenvalue criterion of >1.0.

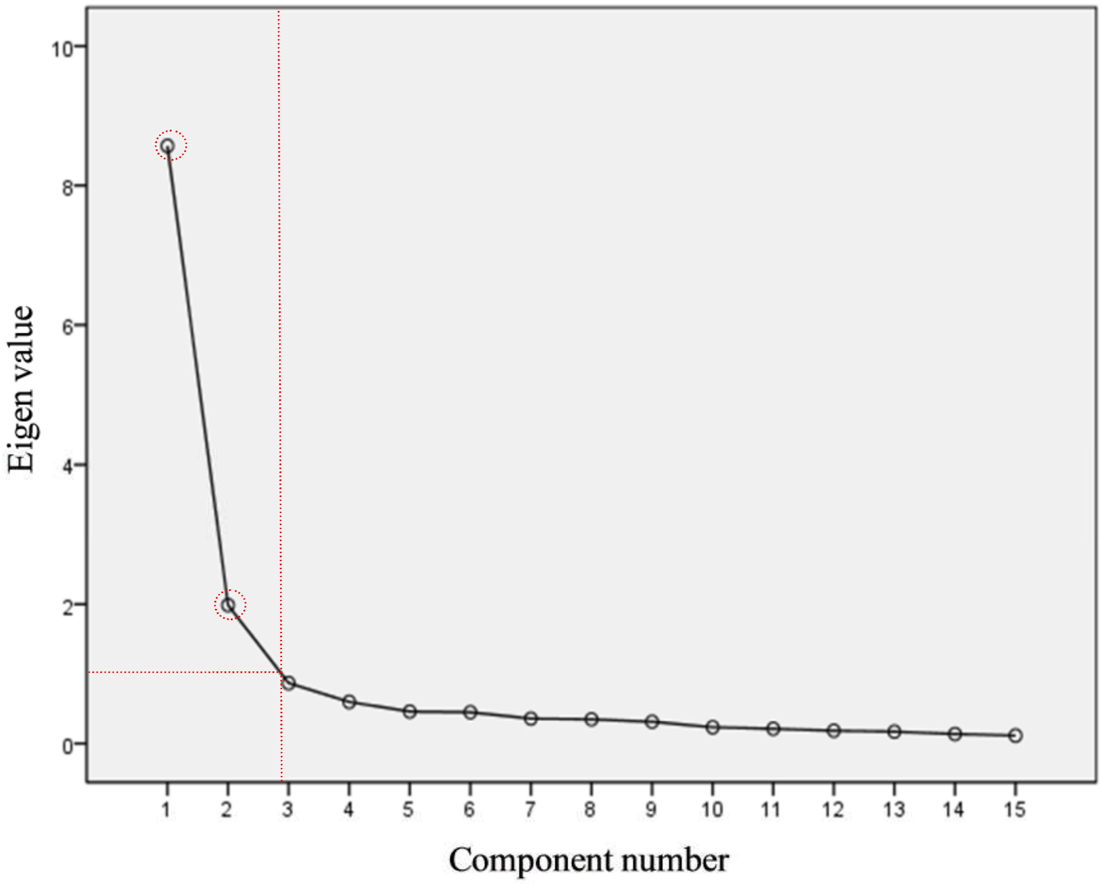


Figure 20. Scree plot showing the eigenvalue for the 15 component and the extraction of the first two components.

5.6.2. Semantic scale loadings

Table 16 displays the item loadings for each semantic scale. The first dimension is best explained by four of the scales; 'relaxed-stressed', 'comfortable-uncomfortable', 'at ease-anxious' and 'calm-agitated', with strong loadings of 0.900, 0.897, 0.890, 0.885 respectively. All other scales were highly loaded. Based upon these semantic scales, this dimension was defined as 'Relaxation'. Grounded upon this interpretation, it can be said that this is an emotional reaction to the ward soundscape and the dominant response that the soundscape elicits.

The second dimension is best explained by two scales; 'curious-apathetic' and 'intrigued-bored' with loadings of 0.832 and 0.817 respectively. The third loading on the 'alert-unprepared' semantic scale was lower at .651. This dimension was thus classified as 'Interest & Understanding' based on these scales. This represents a more cognitive reaction to the soundscape suggesting a level of thought processing occurring. Figure 21 clearly shows the cluster of responses relating to the two dimensions.

Semantic scale	**Principal Component**		**Scale reliability analysis (Cronbach's α)**
	1	2	
Relaxed – Stressed	.900		.858
Comfortable - Uncomfortable	.897		.874
At ease - Anxious	.890		.876
Calm – Agitated	.885		.846
Tolerant – Irritated	.878		.723
Peaceful - Troubled	.873		.808
Content - Annoyed	.854		.867
Satisfied - Frustrated	.844		.848
Undisturbed - Disturbed	.840		.809
Reassured - Worried	.761		.824
Attentive - Distracted	.730		.674
Unconcerned - Concerned	.714		.876
Curious - Apathetic		.832	.587
Intrigued - Bored		.817	.408
Alert – Unprepared		.651	.538
Variance explained (%)	56.8	13.2	

Table 16. PCA item loadings for each of the principal components (obtained through a varimax rotation) along with reliability measurement for each scale with item loadings of less than 0.3 omitted to improve clarity. *Note,* key scales highlighted.

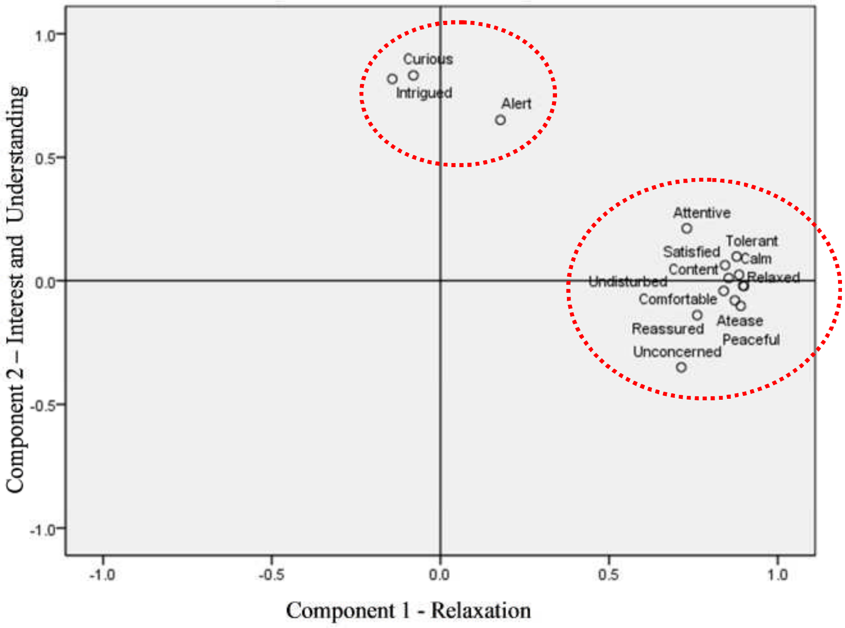


Figure 21. Rotated component model showing the factor loadings of each semantic.

5.6.3. Scale reliability

A Cronbach's α reliability test was carried out to understand the internal consistency of each of the scales in measuring the corresponding dimension (table 16). Twelve of the 15 scales related to the 'Relaxation' dimension recorded high reliability; overall Cronbach's α = .961. This shows high internal consistencies for these scales in measuring the 'Relaxation' element of the soundscape. Both the 'relaxed-stressed' and 'comfortable-uncomfortable' scales, individually recorded the highest internal constancy, Cronbach's α = .858 and .874 respectively. This suggests these are the strongest scales for measuring the 'Relaxation' dimension of the soundscape and support scale reduction to these two main scales.

The three 'Interest & Understanding' scales recorded a lower levels of reliability; overall Cronbach's α = .693. This showed only moderate internal consistency in the scales. Both 'curious-apathetic' and 'intrigued-bored' recorded independent Conbach's α = .587 and α = .538 respectively, suggesting moderate to weak internal consistency signifying possible ambiguity in the interpretation of these. To explore this further, 'alert-unprepared' was removed to improve the internal consistency of the dimension scales which resulted in Cronbach's α = .721. This suggested this scale was causing most ambiguity.

5.6.4. Correlation coefficients

To establish the correlations between the semantic scales, Pearson's coefficient of correlation were calculated. The 'relaxed-stressed' scale showed a significant positive correlation with 'comfortable-uncomfortable' (r = 0.827, p = <0.01), 'calm-agitated' (r = 0.818, p = <0.01) with 'at ease-anxious' having a lower correlation of r = 0.794, p = <0.01. This suggest that the principal scale relaxed-stressed describes the same response found within the next three high factor loading scales, as described above. This relationship is evident in Figure 3 by the high cluster of results around dimension 1. ‘Interest & Understanding’ showed only moderate but significant correlations between ‘curious-apathetic’ and ‘intrigued-bored’ (r = 0.564, p = <0.01). This suggested that the two scales measure a similar response from individuals but in a less clear way.

5.6.5. The Perceptual Space: Testing the initial interpretation of perception[1]

The perceptual space was used to highlight the response to each of the 19 sound clips (Figure 22). Taking the dimensions independently, three clusters were formed passing from left (stressed) to right (relaxed). Referring to the clip content descriptions presented in table 13, the most stressed responses were obtained from clips which had dominant foreground features including, a patient crying out, a steriliser machine, and prominent monitor sounds. The second cluster was mainly formed from a mixture of medical equipment, human and background occupational sounds. Interestingly, the majority of these clips were recorded from within the ward bay areas where patient beds were located. The most relaxed responses came from corridor recording which included background occupational sounds (footsteps, doors opening and closing). On the secondary dimension, interested response came from generally the most negative ‘Relaxation’ sounds. Therefore, this potentially starts to formulate the suggestion that understood sounds facilitate relaxation to a certain degree. This was a tentative visual assessment of perception but demonstrated the rich information defining perception can give which further testing clarified and is discussed in the later chapters.

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[1] All dB(A) values were calculated as a 95% average to improve accuracy and account for variations in levels through the 20 second clip.

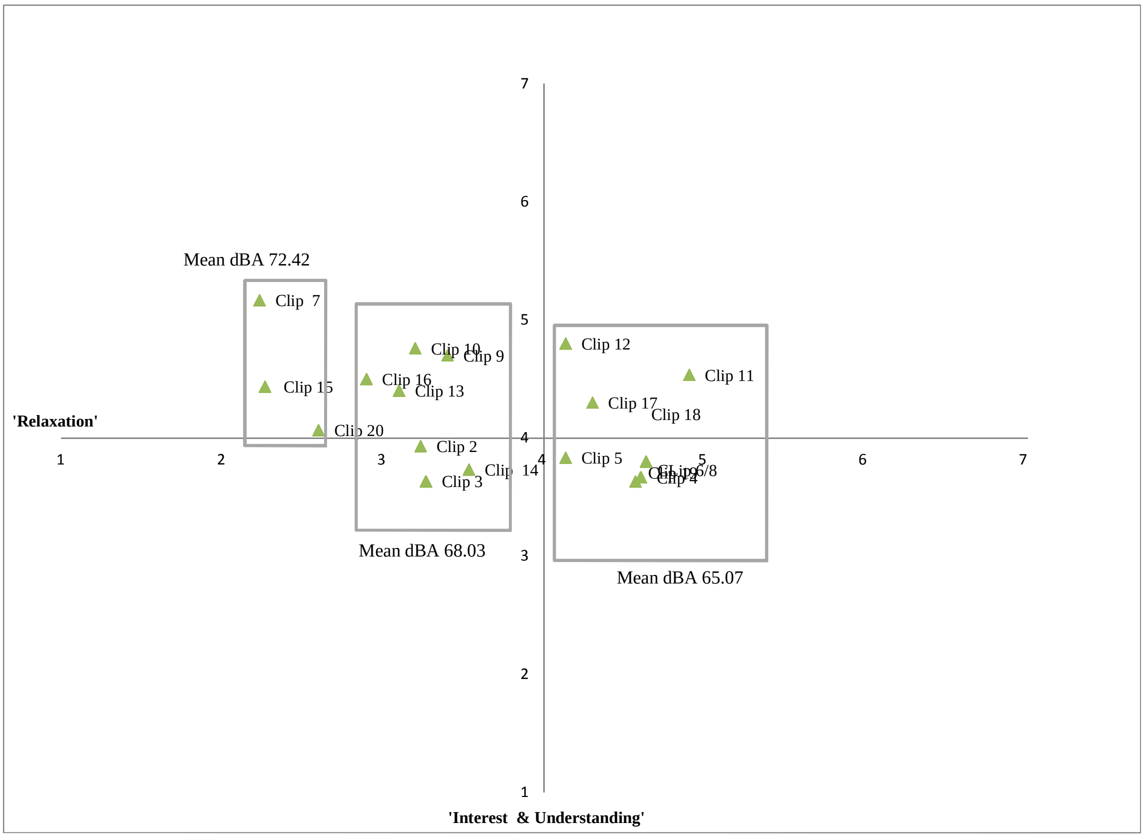

Figure 22. Perceptual space of the emotional-cognitive response measured using clip rating scores from the highest item loaded scales for each dimension; ‘Relaxation’ = ‘relaxed-stressed’ and ‘Interest & Understanding’ = ‘curious-apathetic’.

Therefore, soundscape interventions could be tested to see how to manipulate this perception. For instance, based on the questions that arose from Chapter 4, these included does natural sound produce a more positive response and does information about the soundscape aid understanding and thus, ‘Relaxation’?

5.7. Discussion

As this chapter has shown, it is important to consider the multiple dimensions on which a soundscape can be evaluated and understanding how a place makes a person feel emotionally. This is more use to planners and decision makers than understanding just the acoustical signal of the soundscape (Cain et al., 2013). Acknowledging this, semantic validation yielded comparable language to the interview with the word ‘calm’ the most frequently used positive word. Nurses reported:

N: we use the word calm; it would be nice if it was calmer

This is supported by Axelsson et al., (2010) who found calmness was contained within a principal dimension that described an urban soundscape. Moreover, they cite Russell & Snodgrass’ (1987) idea that environmental appraisal is represented by two components of exciting and calming, with the results of Cain et al., (2013) also supporting this.

The semantic validation then allowed 15 bipolar semantics scales to be made. The PCA revealed a two dimensional model of perception to the CT soundscape. This is in line with other sound quality, soundscape and environment research (Russell, 1980; Axelsson et al., 2010; Jennings et al., 2010; Giudice et al., 2010; Cain et al., 2013) in describing perception towards a stimulus within a two-dimensional space. The principal dimensions, labelled ‘Relaxation’ and ‘Interest & Understanding’ create these and described not only an emotional response but also a cognitive element relating to a sense of stimulation that comes from interest. These orthogonally related components simplify the perception of the CT ward soundscape to an emotional-cognitive response. This extraction equates to the logic behind the coping methods of acceptance and habituation to sounds within the CT ward, described in Chapter 4. From the visual representation in the perceptual space it appeared from the results that if a sound causes curiosity it is linked with less ‘Relaxation’ and so understanding the soundscape may facilitate ‘Relaxation’.

The principal dimension ‘Relaxation’ accounted for 56.8% of the variability within the data set and described the emotional reaction - the feeling from the hearing the soundscape. As hospitals should minimise anxiety and promote healing through the creation of an overall inviting calming and engaging environment (Douglas & Douglas, 2005) this inherently tied to feelings of ‘Relaxation’. This is defined by this dimension. Arguably, most of the semantic scales represent this dimension and such a result is unsurprising. However, it should be remembered that the semantics were obtained from patients, nurses, and members of the public as a direct result of exposure to the CT ward sounds thus generating validity to this extraction. Furthermore as the studies of Cain et al., (2013) and Irwin et al., (2011) suggest and show, the response to hearing a soundscape is emotional as the amygdala, the emotional regulator in the brain, is activated by urban soundscapes. As hospital environments are emotively charged spaces, such responses may be more pronounced, although this suggestion would require a robust study to formally confirm this.

‘Interest & Understanding’ suggests a cognitive reaction and appraisal of the soundscape. This secondary dimension to perception showed that the healthcare soundscape is partly one which is involved in a level of understanding. Therefore, this dimension relates to the information content within the soundscape. The scales ‘curious-apathetic’, ‘intrigued-bored’ were found to represent this appraisal connected to familiarity and information. Information content within the soundscape is not new concept as Irwin et al., (2009) found that ‘information formation’ had positive loading within a ‘vibrancy and information content’ dimension explaining 23.62% of the variance when five participants rated 219 urban soundscape clips. Such results, acknowledge information’s importance within soundscape perception. In support, Axelsson et al., (2010) state as part of their main findings that informational properties are a substantial contributors to soundscape perception. The work of Truax (1984) supports this extraction through a more theoretical interpretation. As explained at the start of the thesis, Truax (1984) explains sounds can be linked on their common basis - communication. This communication approach deals with the transfer of information (Truax, 1984) and this considers the cognitive processes that underlie it, which is apparent here with ‘Interest & Understanding’ being a dimension of perception.

These results are reinforced by Guillen & Lopez Barrio (2007) and Hall et al., (2011) who aimed to discover the perceptual properties of the urban soundscape. Their results (table 17) are comparable as they include notions of relaxation and interest. It is noteworthy that the second dimension in the case of Guillen & Lopez Barrio (2007) accounts for a similar level of variance within the results, 13.64% compared to 13.2% in this study. Therefore, based on such interpretations it is clear that the emotional-cognitive response for soundscape perception is somewhat comparable across environmental contexts. This strengthens the extracted components for the CT soundscape along with the theoretical interpretation.

Semantic scale (Guillen & Lopez Barrio., 2007)	**Principal component**		**Semantic scale (Hall et al., 2011)**	**Principal component**	
	1	2		1	2
Pleasant - Unpleasant	.894		Pleasant - Unpleasant	.825	
Relaxed - Stressed	.892		Calm - Agitated	.895	
Comfortable - Uncomfortable	.905		Comforted - Worried	.848	
Informative – Not informative		.663	Informed - Confused		.788
Variance of explained (%)	41.84	13.64	Variance of explained (%)	47.58	23.82

Table 17. The PCA results of two urban soundscape studies showing similar perceptual dimensions which related to the extracted emotional-cognitive response presented in this chapter.

As stated this emotional-cognitive response equates squarely to the logic behind the coping methods - the acceptance and habituation of sounds described in Chapter 4. Explaining this, patients showed that understanding sound lead to the acceptance of them which lead to a more positive response to the CT soundscape. Therefore, these findings can be related to the conceptual model as this depicts the subjective response to the soundscape. This can be formally called the emotional-cognitive and response, based on these findings (Figure 23).

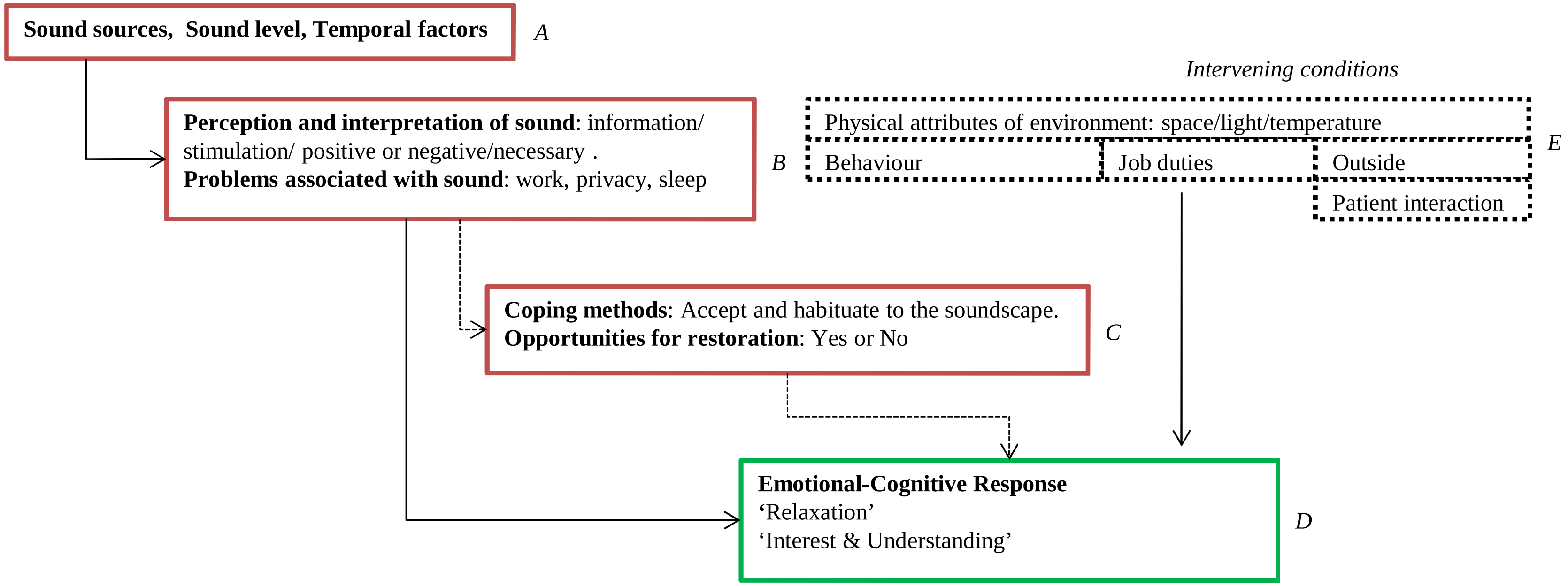

Figure 23. Conceptual model depicting the perception of the healthcare soundscape with the emotional-cognitive response now simplified.

5.7.1. Limitations

A number of limitations with the results are acknowledged and detailed below:

- Arguably, a semantic differential scale has a number of limitations. As the definition of the words can vary between participants. For instance 'distracted' can be equally positive and negative, that is distracting worry being positive and distracting attention being negative. Raimbault (2006) suggests that averaging calculations of semantic answers can be misleading as inter-individual differences show a difference in interpretation of the scale which the mean does not detect. However, the scales were developed from interviews and experimental studies. Therefore, the chosen semantics should match people's interpretation/definition of them in relation to hearing the sounds of the CT ward, supported by the reliability analysis
- Cited by Cain et al., (2013), Barbot et al., (2008) notes that the meaning of adjectives can be difficult to interpret by subjects and can even be difficult between subject, which is why Cain et al., (2013) described their emotional dimensions with multiple semantics. However, pairing of these may mean that there is variation in the semantics describing a dimension. This is why a single adjective was used and furthermore, why the reliability of them was measured.
- Only four healthcare professionals could be recruited limiting the validity to this group. In order to establish the dimensions in a more robust way for this group further evaluations may need to take place. However, convenience sampling was the most feasible method of recruiting given the time frame. The sample was selected based in it potential level of insight into the specific theory being

investigated which has been advocated when using this sample method (Uwe, 2006; Patton, 2002).

5.8. Conclusions from Chapter 5

Defining the emotional-cognitive response provided a set of scales to measure perception and a perceptual space to present the results. Importantly, Guastavino (2006) advocates that physical interventions should be conducted after the psychological exploration of cognitive categories which this study has done. This work provides a perceptual space to assess the effectiveness of interventions based on their ability to manipulate the emotional-cognitive response to the CT soundscape. These interventions fall into two categories, physical and cognitive described in detail in the following chapter.

CHAPTER 6

PART C: TESTING SOUNDSCAPE INTERVENTIONS

6.0. Introduction

This chapter describes the testing of soundscape interventions that potentially create a more positive emotional-cognitive response. This addresses the main aim of the project and linked the qualitative conceptual model of hospital ward soundscape perception to laboratory work. The chapter describes the rationale behind these interventions, along with the results of the testing with a discussion and limitations given. Therefore, the aims of this study were summarised as:

- To test soundscape interventions with a robust rationale behind them using a listening evaluation.
- Select the most appropriate intervention for testing in-situ within the CT ward to gain a further understanding of its effect.

6.1. Soundscape intervention rationale

The soundscape interventions were derived from the conceptual model which suggested that physical and cognitive interventions may improve the perception of the soundscape (Figure 24). These interventions acknowledged the coping methods highlighted in the conceptual model to include, two physical interventions of natural sounds and steady state sound, along with a cognitive intervention in the form of information about the sounds. At this point it is important to note that the interventions were tested to improve the patient response to the CT soundscape. This direction was chosen due to the pragmatic issues of obtaining a healthcare professional sample. Moreover, the interventions developed a strong patient orientated rationale behind them discussed below.

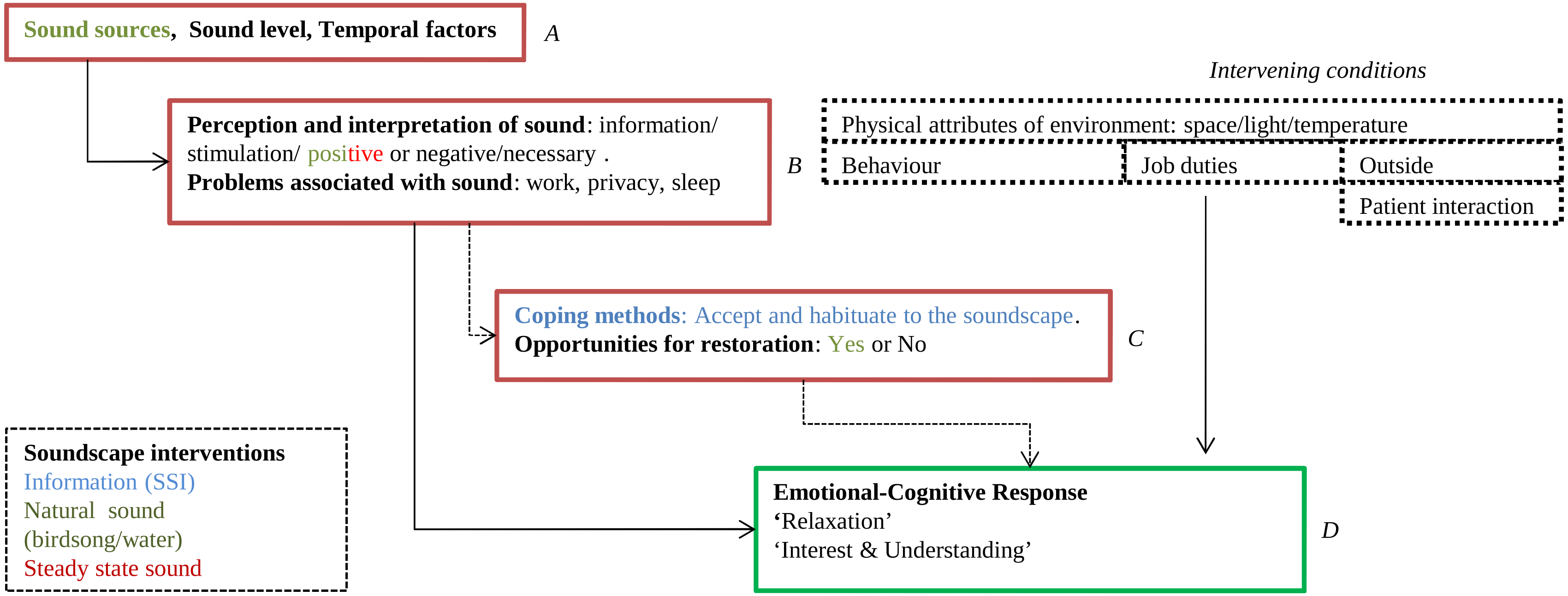

Figure 24. Conceptual model highlighting soundscape intervention in relation to coping methods.

6.1.2. Natural sounds (NS)

Urban soundscape work has explored the effect of natural sounds on the individual. When assessing the soundscape of two cities by Yang & Kang (2005) interviewees were requested to classify 15 verbally described sounds into either favourite, neither favourite nor annoying or annoying. More than 75% of participants were favourable to water sound and birdsong. Interestingly 93% of people aged over 65 favoured birdsong, similar to the mean age of the CT ward demographic. Yang & Kang (2005) suggest this is because as people grow older their sound preferences become shaped by experience and the older people are the more emotion people have with the sound environment. Yang & Kang (2005) cite (Porteous, 1996) that a soundscape is an emotive environment not an intellectual one. Natural sound should therefore elicit a more positive emotional response when mixed with the CT soundscape.

Guastavino (2006) used a questionnaire to investigate the sound quality of two urban French cities. Psycholinguistic analysis of verbal descriptions showed that positive expressions were used to describe human and natural sounds. Sounds indicating the presence of natural elements (wind, water and natural elements) were always appreciated, in agreement with the biophilia hypothesis – the attraction towards nature hypothesis (Guastavino, 2006). Moreover, quiet, relaxing and tranquil environments cannot be simply reduced to an absence of noise (Guastavino, 2006). Therefore, providing a positive sound in a soundscape perceived as ‘noise’ should facilitate this concept. Furthermore, gentle background music and the sounds of nature such as waterfalls or streams, just the sound of water or birdsong, can have a very positive effect on psychological states and perception of the hospital environment (Biley, 1996).

6.1.3. Steady state sound (SSS)

Masking sounds is potentially a way in which negative sound can be controlled and can be defined as the presence of one sound that renders another sound undetectable (Plack, 2005, p, 245). Loewen & Suedfeld (1992) tested the effect of masked and unmasked office noise on arousal, stress and cognitive performance on 15 students. Although the small sample, the notions presented in the paper are useful. Three conditions included; office noise (at 54dB(A) and 60-66dB(A)), masked office noise 59dB(A), and no extraneous noise. The authors suggest that noise produces a decrease in task performance, however the Yerkes-Dodson law predicts curvilinear association between performance and arousal and suggest noise follows this. Therefore, masking should lead to improvements, that is, the absence of sound has a detrimental impact on performance. Loewen & Suedfeld (1992) speculated that the sound of an ocean would not have the same effect on arousal and mood as an identical dB increase in traffic noise. The results were captured through a number completion task, topic completion task, Russell Mood Scale and emotional stressor questionnaire. Masked noise which was louder than unmasked led to the highest ratings of arousal, but did not contribute to distraction or stress and recorded the best performance on the cognitive task. They suggest that masking qualities can be beneficial, even if it does increase ambient sound level in general. Pertinently, presence of disruptive noise may benefit from the provision of white noise masking and may lead to lower stress levels and distraction (Loewen & Suedfeld, 1992). Despite the fact the white noise intervention did not significantly affect pleasantness, masking may be beneficial to the CT soundscape, even if the ambient sound level is raised, as it may distract less therefore assisting relaxation.

Saeki et al., (2004) focused on masking speech with meaningless steady state sound. Results showed this to be most effective noise for masking speech in the case of speech. With lower sound levels, the SPL of meaningless steady state noise needs to be higher. Both these examples support that steady state sound could manipulate the emotional response to the soundscape in a positive way especially as human sounds are a prominent source.

6.1.4. Sound source information (SSI)

The most novel intervention was information, derived from the interpretation of the interview data. As discussed in detail in Chapter 4, this potentially assisted in coping methods of accepting and habituating to the soundscape. Topf (2000) suggests personal control is the capacity to regulate stress with a negative event, which may be behavioural, decisional, cognitive-behavioural and pertinent here, cognitive (having information about the stressor, reframing from the stressor, thinking about something else). As such, it is postulated that information can facilitate this sense of personal control. Indeed, Griffin et al., (1998) commented on the stress parents' face in having a child in a neonatal intensive care unit remarking because the environment is stressful, parents should verbalise concern and, for example, nurses should clarify when alarms are false or are unanswered. From a soundscape perspective, Axelsson et al., (2010) state that the informational components are a substantial contributor to soundscape perception, thus highlighting the importance to the individual of understanding the sound environment.

Baum et al., (1981) suggest that having accurate information of what one may feel or will happen in threatening or painful situations can reduce distress - a useful concept when considering exposure to the CT soundscape. In a sense this is emotion focused coping (Folkman & Lazarus, 1993, Folkman, 2008). Baum et al., (1981) suggest possible interventions utilising information include providing people with accurate descriptions of what will happen or what they might feel or by giving them coping strategies. For example, knowing what one may feel during a medical examination should reduce uncertainty when symptoms are actually experienced (Baum et al., 1981). This theory can be applied in the context of the hospital soundscape and theoretically this should facilitate appraisal of the situation as non-threatening thus improve the emotional-cognitive response.

There are two possible types of information. Internally focused information is more appropriate in medical situations (for example, pain) whereas externally focused information is effective in crowd control and noisy situations (Baum et al., 1981). Investigating this, the authors carried out an experiment to look at the mediating influence of information and familiarity with stressful situations. Using a crowded situation, 12 students participants carried out tasks to find 24 items within a bookstore. Subjects were spilt and given different information; what might happen (situational information), emotional information, sensory based information (feel uncomfortable-anxious, et cetera) and positive information.

The authors found familiarity effects the usefulness of information. Situational information was more effective in reducing stress than sensory when subjects were unfamiliar with their surroundings but familiar subjects benefitted equally. Baum et al., (1981) suggest that the effectiveness of information in reducing stress will vary as a function of how well it addresses the concerns of the people in the setting. Therefore information needs to fit the experiences of the individual.

This suggests that when patients enter the hospital ward at first it is novel. Situational information may therefore be effective in facilitating habituating and implicit learning to the sounds. Thus, as understanding grows the individuals' emotional response to the soundscape may develop more strongly as positive, via accepting.

Baum et al., (1981) cite Fuller et al., (1978) who found that routine pelvic and breast examinations remain unpleasant after multiple experiences yet information about the sensory aspects of the examination was associated with a reduction in distress because information was more specific and therefore offered control. Even redundant information can serve as a reassuring function and address the concerns that are not as salient as others (Baum et al., 1981). Therefore, providing information that may be obvious may be a way in creating a positive perception of a hospital soundscape. Baum et al., (1981) acknowledges that these findings may be more uncertainty in medical situations, something that can be considered here.

Concurring, Topf (2000) suggests that information, regarding ones condition, can make a patient feel less stressed within the hospital environment. This is supported by Williams & Irurita (2004) who describes a level of knowing referring to the level of information a patient has concerning a situation or environment. The authors suggest that patients experience feelings of reduced personal control and feeling of emotional discomfort when experiencing a lack of relevant information within a hospital environment. Here, Williams & Irurita (2004) are referring to information on the patient's condition rather than the environment. Poroch (1995) is cited stating that patients need the right level of information and it has been found that anxiety of patients increases when they are provided with too many technical details. Therefore, colloquial language to describe the soundscape was needed to provide sufficient sound source information to individuals but not concern them

Based on this and the research by Baum et al., (1981) information was situational, for example, detailing sound sources and associated causes, to feed the implicit learning and therefore, habituation. Due to the complexity of sources and the different sounds that occur it would not be possible to suggest what the sounds mean and this could possibly increase anxiety. More broadly, understanding if this can create a positive perception of the soundscape may also show the importance of understanding the hospital environment, particularly for patients and visitors, in making them feel at ease.

6.1.5. Music

Music was not used as an intervention despite its use within healthcare, often relating the music therapy. Biley (2000) conducted a literature review focusing on using music as a nursing intervention which led the author to conclude that the research shows positive physiological changes meaning more confidence is placed in the psychological value of music. Likewise, other studies have suggested the benefit music has in the psychological wellbeing of patients (Thorgaard et al., 2004; Thorgaard et al., 2005). Music has also been used to relax staff during the surgery although Liu & Tan (2000) point out that this is controversial, as musical tastes differ among patients, staff, and elderly patients or staff may not appreciate music that younger individuals use to relax.

Importantly, music is not part of the existing soundscape whereas natural sounds are already present to a certain degree within the environment, for example, the sound of birds. For this reason exploring the promotion of these sounds was more relevant as they are present within the ward soundscape, thus maintaining the context relationship of soundscape perception. The interview data suggested that music may be met with mixed responses as some patients suggested that it would be intrusive, concurring with Liu & Tan (2000).

6.2. STUDY C1: SOUNDSCAPE INTERVENTIONS USING LISTENING EVALUATIONS

The aim of the study was to utilise the perceptual space and the emotional-cognitive dimensions to test the effectiveness of these soundscape interventions on eliciting a more positive response. The study tested the following hypothesis:

H_0 – There will be no difference in scores on the emotional-cognitive dimensions between the existing soundscape and intervention soundscape.

H_1 – There will be a significant positive difference in the overall scores on the emotional-cognitive dimensions between the existing soundscape and physical intervention soundscape.

H_2 – There will be a significant positive difference in the overall scores on the emotional-cognitive dimensions between the existing soundscape and cognitive intervention soundscape.

6.2.1. Method and Study Design

6.2.2. Sound stimuli

Twelve sound clips were used selected from the original 19 based on the most salient clips. This was to reduce the time taken for participants to complete the study. Importantly, these still retained the dominant feature upon which they were originally selected. Taken collectively, they represented a broad section of the CT soundscape (table 18).

Clip Number	Recorded dB(A) 95%ile mean over clip period	Playback dB(A) 95%ile mean over clip period	Difference (dB(A))	Clip Content
1 (*practice and repeated at end)*	68.77	72.31	3.54	People talking and sterilising machine starting and continuing masking other sounds.
2	56.25	65.78	9.53	Talking and footsteps in background. Doors opening and closing with object banging.
3	56.09	63.24	7.15	Talking and footsteps in background. Trolley passing, doors opening and closing, monitor beeps in background.
4	52.40	64.67	12.27	Quiet corridor. Monitor beeping sounds in background.
5	62.19	68.20	6.01	Deep rumble of a passing trolley. Some background talking.
6	61.37	68.03	6.66	Talking and footsteps in background. Patient screaming intermittently, trolley passing.
7	60.19	63.78	3.59	Talking and footsteps in background. Trolley passing.
8	60.19	67.56	7.37	Talking in foreground from nurse taking patient observations, monitor beeping, and car passing in background
9	48.03	62.34	14.31	Quiet ward bay with private conversation between nurse and patient in foreground.
10	54.66	65.43	10.78	Quiet ward bay with beeps rustling and talking in background.
11	63.42	69.64	6.22	Rustling of bins being changed in ward bay, water running, and background talking.
12	65.43	68.75	3.31	Nurses talking loudly and laughing. Monitor beeps, floor buffer in background.

Table 18. Table of sound clips and content for the 12 sound clips used in the soundscape intervention listening evaluation, based upon a selection of clips containing a broad range of features.

6.2.3. Questionnaire

The questionnaire used to obtain the subjective response was the same format discussed in Chapter 5 (Appendix 4.1.). The four rating scales, two from each of the principal dimensions ‘Relaxation’ and ‘Interest & Understanding’ were used. Thus, ‘Relaxation’ was measured using the scales ‘relaxed-stressed’ and ‘comfortable-uncomfortable’. ‘Interest & Understanding’ included ‘curious-uninterested’ and ‘intrigued-bored’. At the end of the questionnaire basic demographic questions and thoughts on the soundscape were asked to expand on the quantitative data and aid interpretation.

- *Were there any sounds that particularly affected you?*
- *How did you feel overall when listening to the recordings?*
- *How does having information on the soundscape make you feel?*

SSI, in the form of a table detailing sounds sources within the sound clip were presented on the response sheet. This information was designed from the content of the clip (Appendix 4.2.). The information was the same for each clip rather than specific details of the individual sources within each of the 12 clips. For SSI to work in the actual ward environment, the soundscape would be constantly varying so information would have to be generic in nature, thus justifying this approach.

6.2.4. Study design and procedure

The study utilised a repeated measure design to compare responses across conditions. This required a smaller sample size than using a between subject design which can be justified given the time constraints of the project. This utilised the four soundscape conditions control, natural sound intervention, steady state sound intervention, and SSI. Each intervention was applied to all 12 sound clips. The procedure was identical to the previous laboratory studies described in Chapter 5 Study B2. Sound clips lasted around 20 seconds presented sequentially with a shorter 10 second inter stimuli period to discriminate between clips. Participants completed each of the four conditions on separate occasions. Evaluations were conducted a minimum of two day apart to avoid demand effects however, this varied between participants to accommodate availability. To avoid order effects, participants were split into four groups with the condition sequence order randomised (table 19) for each. This counterbalancing was achieved using a Latin square method and further to this, each group started the evaluation on a different sound clip, either 1, 2, 3 or 4, to further control for bias within the design of the experiment.

Group	**Participant number (n=)**	**Condition sequence**
Group 1	1-6	conditions a, b, c, d
Group 2	7-12	conditions b, c, d, a
Group 3	13-18	conditions c, d, a, b
Group 4	19-24	conditions d, a, b, c

Note condition A = control, condition B =NS, condition C = SSS, condition D = SSI.

Table 19. Showing participant group allocation and condition order.

6.2.5. Analysis and sample

Firstly, reliability analysis of the scales measuring each dimension was tested across conditions to ensure that the results could be justifiably compared. This was carried out using a Cronbach's α as in Chapter 5. Main effect was analysed using a repeated measures analysis of variance (ANOVA) and was performed using statistical software SPSS 19. ANOVA measures the variability in scores due to individual differences (all scores calculated against each other) and variability due to random error which as a result tends to give rise to a more sensitive and powerful test (Dancy & Reidy, 2007, p, 313). Although using an ordinal scale of measurement, this parametric form of analysis was used as supporting literature from soundscapes work (Axelsson et al., 2010; Kang, 2007; Yang & Kang, 2005a; Payne, 2012) used parametric test when using comparable scale methods. The effect size (eta) was set to 0.25 to look for a small effect as comparable research of Payne (2008) found small to medium effects (.10 to .25

eta) when assessing specific attributes of a soundscape. Likewise, Axelsson et al., (2010) used linear regression to determine the perceptual attributes of the urban soundscape and found a medium to large effect size. Based on this and the nature of looking at a new soundscape intervention, SSI, this small effect size can be defended.

Sample size was calculated using GPower3 software (Faul et al., 2007). Setting a power level of .80 with an effect size (eta2) of 0.25 for a repeated measure ANOVA with 4 conditions and 1 group, sample size was calculated to be 24 (α level set 0.05 resulting in a test power of 0.81, CI 95%). The 24 participants had a mean age of 32 years (SD 10.13yrs), with 13 male and 11 female. The sample included a range of demographics from students, researchers, a teacher, and priest. No healthcare professionals were recruited.

6.3. Results[1]

6.3.1. Scale reliability

'Relaxation' recorded high reliability, Cronbach's α = .921 across all conditions. Likewise 'Interest & Understanding' recorded a reliability value of Cronbach's α = .895, suggesting that the scales were consistent in measuring the emotional-cognitive response and thus allowing valid comparison between conditions.

6.3.2. Main effect of interventions on 'Relaxed' and 'Interest & Understanding' dimensions

Assumptions of normality were met (Appendix 4.3.) although sphericity was violated and accounted for using Greenhouse-Geisser correction. The results showed a significant difference across all conditions on the 'Relaxation' dimension; (F (3,751) =

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[1] All analysis was based using the combined scores for each dimension unless stated otherwise, that is, Relaxation was measured using the scores of both stressed-relaxed and comfortable-uncomfortable; Interest and Understanding using curious-uninterested and intrigued-bored.

13.991, p = .001). A small overall effect size of 0.05 (partial η^2) showed that 5% of the variation in the emotional-cognitive response can be accounted for by the differing conditions. Pairwise comparisons, with a Bonferroni correction to account for the increase in pairwise comparisons, showed a significant difference between the control and all interventions (Figure 25/26). NS had a large difference causing a change in response of 10.1%; (mean difference NS = .445, p = .001),CI (95%) 0.249-0.637). SSS had a smaller difference causing a 3.3% change; (mean difference SSS = .208, p = .008. CI (95%) 0.038-0.378). Finally, SSI was successful in producing a difference in scores half that of natural sound of 4.7%; (mean difference SSI = .247, p = .001), CI (95%) 0.089-0.406). Notably, based on the mean scores, these produced a positive movement.

A non-significant difference was seen between conditions on the 'Interest & Understanding' dimension (F(3,764) = 1.447, p = .229). Pairwise comparisons showed that there was smaller difference between the control condition and interventions (Table 20). The mean difference of NS = 0.00, p = 1.00 corresponding to a 0.6% change. Hoever, SSS caused a larger non-significant change of 4.7% , mean difference SSS = -.123, p = .338. Finally, SSI produce a small effect mean difference = -.066, p = 1.00.

Emotional-Cognitive Response	**Mean Difference to Control condition**	**P-value**	*CI 95%* **Lower bound – Upper bound**	**Percentage change** *(Control vs. Intervention)*
'Relaxation'				
NS	.445	.001	0.249-0.637	10.1%
SSS	208	.008	0.038-0.378	3.3%
SSI	.247	.001	0.089-0.406	4.7%
'Interest & Understanding'				
NS	0.00	1.00		0.6%
SSS	-.123	.338		4.8%
SSI	-.066	1.00		2.0%

Table 20. Difference and change in emotional-cognitive response caused by each condition.

It can therefore be concluded that, in this experimental setting, ‘Relaxation’ was most effected by soundscape interventions, particularly NS and SSI. This supports findings from the previous experimental data that ‘Relaxation’ is the strongest dimension in measuring the emotional-cognitive response to the CT ward soundscape. The results suggest rejection of the null hypothesis on the ‘Relaxation’ dimensions and acceptance on the ‘Interest & Understanding’ dimension.

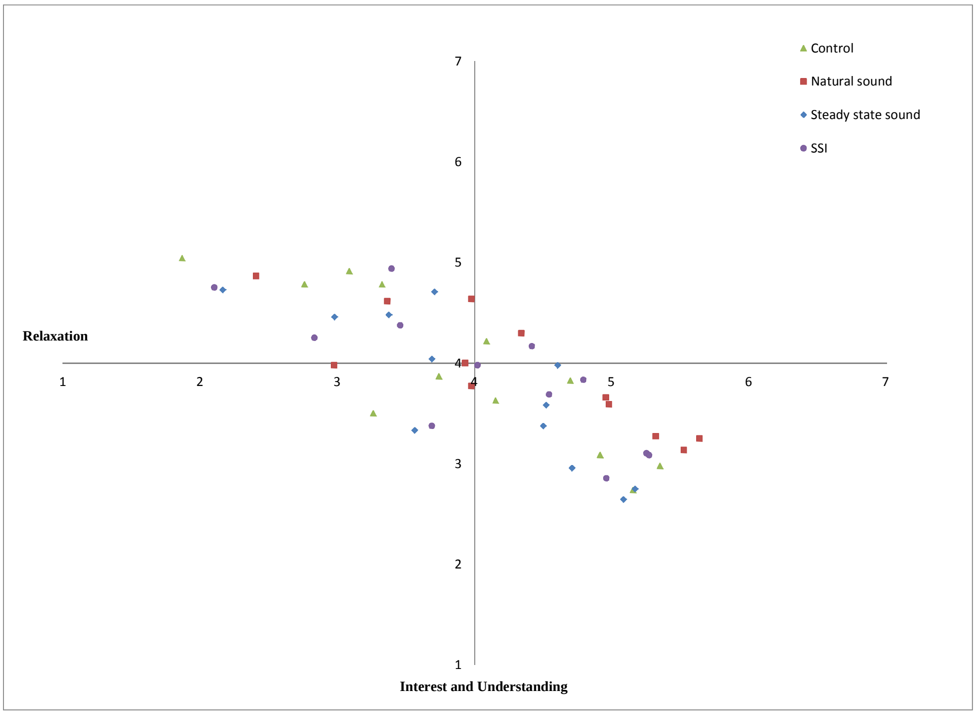

Figure 25. Showing the effect of each intervention (left) along with the emotional cognitive scales (right) using the mean scores for each condition. *Note*; increase in ‘Relaxation’ in interventions with the highest natural sounds and SSI.

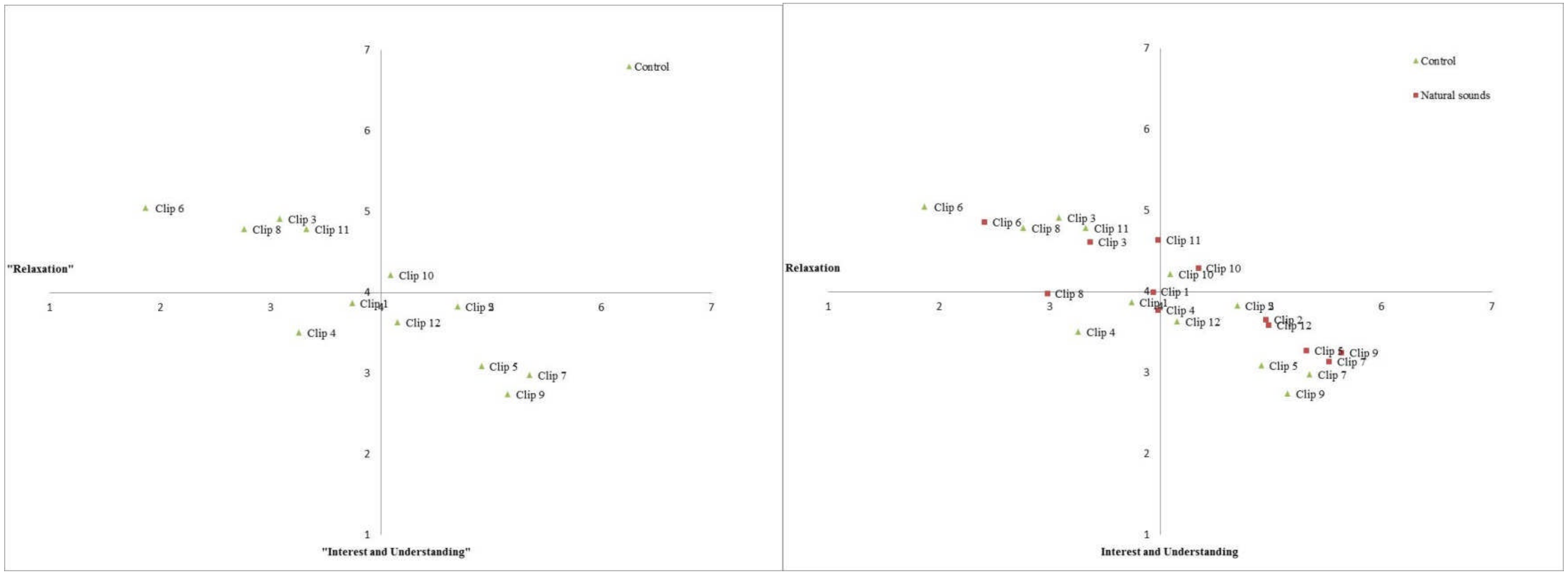

Figure 26a. The response to each sound clip across the Control and NS conditions. *Note*, significant (p = <.05) variation along ‘Relaxation’ dimension and condition B resulting in a significant (p = <.05) positive shift in responses along the ‘Relaxation’ dimension. A non-significant difference (p = >.05) was observed across the ‘Interest & Understanding’ dimension.

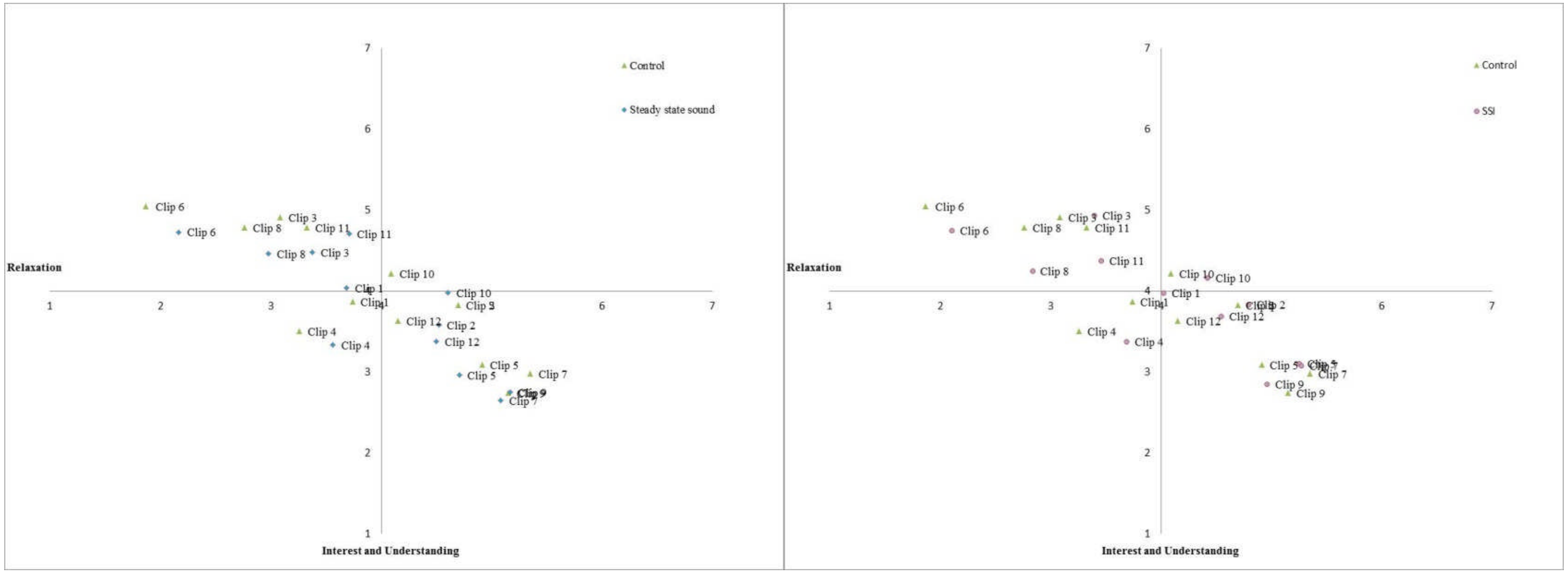

Figure 26b. The response to each sound clip across the Steady state sound and SSI conditions. *Note*, significant (p=<.05) variation along 'Relaxation' dimension and NS resulting in a significant (p = <.05) positive shift in responses along the 'Relaxation' dimension. A non-significant difference (p = >.05) was observed across the 'Interest & Understanding' dimension.

6.3.3. Post hoc analysis of main effect and clip ratings

A post hoc repeated measure ANOVA with a Bonferroni, accounting for increase in pairwise comparisons, was used to look for significant differences in the ratings of individual clips. Supporting the main effect, a significant effect was produced by NS on the ‘Relaxation’ dimension in clip 4 and 12 in comparison to the control soundscape; (mean difference clip 4 NS = .795, p = .014, CI (95%) 0.127-1.46; mean difference clip 12 NS = 0.909, p = .023, CI (95%) 0.093-1.726), shown in Figure 27. These results support the small main effect size recorded above. Furthermore, natural sounds appear most successful in altering the emotional-cognitive response to the healthcare soundscape.

Interestingly, these were the only two clips reporting a significant difference between conditions. As such, it can be said that the overall individual response to the complete soundscape is affected more than the ratings of each soundscape excerpt.

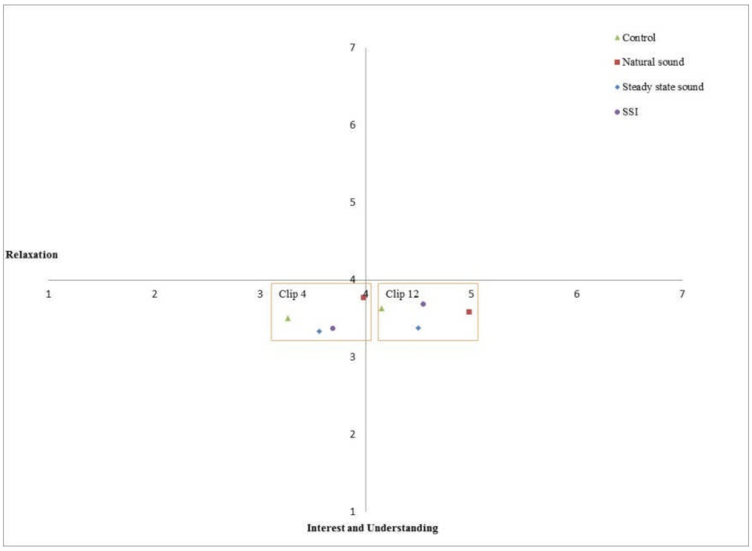

Figure 27. Showing sound clips containing significant variation to the interventions. *Note,* clip 4 and 12 showing a significant positive effect (p=<.05) in scores between the Control and NS conditions on the ‘Relaxation’ dimension.

6.3.4. Correlation between SPL and emotional-cognitive response

One of the premises at the start of the project was that response to the soundscape, or here, the sound clip, would not be related to SPL. Correlation analysis was used to look for this relationship. Using a Spearman's rho test[2], it was found that there was no correlation between SPL and the emotional-cognitive response (table 21), $R^2 = \leq .34$, (all ps, = >.05). This spurious relationship is shown in Figure 28 and can therefore be said that response to the CT soundscape is somewhat independent of SPL. As a result content of the soundscape is the important determining factor.

Dimension and condition	**Correlation coefficient of determination (R^2).**
Interest and Understanding Control	.249
Interest and Understanding NS	.245
Interest and Understanding SSS	.343
Interest and Understanding SSI	.217
Relaxation score Control	-.175
Relaxation score NS	-.224
Relaxation score SSS	-.252
Relaxation score SSI	-.161

Table 21. Spearman's rho coefficient correlation between SPL dB(A) and emotional-cognitive response for each condition. Note, all values non-significant, (p=>.05).

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[2] Non parametric correlation analysis was conducted to account for the lack of normality on the response to each clip.

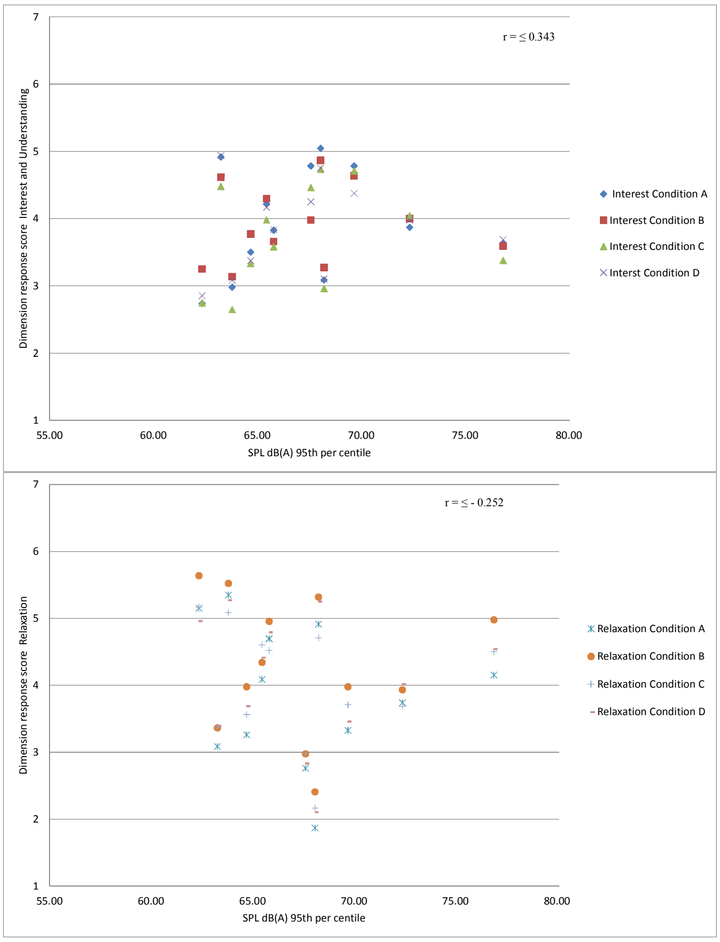

Figure 28. Correlation analysis (Spearman's rho) between SPL dB(A) and dimension scores for each 12 clips. *Note*, 'Interest & Understanding' response top, 'Relaxation' bottom.

6.3.5. Subjective comments from conditions

Although the manner of each intervention was not divulged to participants, subjective response to the conditions showed trends in sounds causing stress and an uncomfortable feeling. These included patient and staff conversation, particularly when private, similar to those expressed in the interviews by real patients. The sounds of the alarms were also described as annoying:

> *Private conversation between patients and nurses I don't feel I should be listening to these.*

> *The crying lady [sound clip 6, a patient with dementia as described in chapter 4] was upsetting.*
>
> *Loud beeping of monitors I find them quite stressful*.

NS condition was described as:

> *Relaxing*
>
> *Brought a soothing dimension and made it more relaxing until the normal sounds made it too loud.*

However, despite positive comments some were negative:

> *I like the birdsong but it could get too much if 'piped' in*.
>
> *Relaxing but could get a bit boring after a while*.

Most participants did not comment on SSS. However, one did, suggesting:

> *White noise and beeps don't make me relaxed*.

This may be because steady state sound is more artificial than natural sounds. It can also be suggested that although a masking benefit may be had, it possibly creates a feeling of tedium which in turn may lead to stress over time which natural sounds may be less susceptible to:

> *[I felt] a mixture of boredom and curiosity to generally unpleasant soundscape.*
>
> *No relief or soothing sounds to character boredom*.

SSI produced mixed responses but two comments suggested it aided contextualisation of the soundscape:

> *Gives better understanding of unfamiliar sounds*.
>
> *[I] can contextualise the sounds more and felt more comfortable knowing what it was*.

6.4. Discussion of results

The study successfully revealed that the soundscape interventions were effective in altering the emotional-cognitive response based upon the two principal dimensions. Both H_1 and H_2 were supported on the 'Relaxation' dimension although a less clear result was apparent for 'Interest & Understanding'. Importantly, the scales reported good internal consistency (Cronbach's $\alpha = \geq .895$) across conditions and therefore, the emotional-cognitive response measured across conditions was reliable.

6.4.1. Hypothesis 1

Hypothesis 1 stated; there would be a significant positive difference in the overall scores on the emotional-cognitive dimensions between the existing soundscape and physical intervention soundscape. Overall, a small but significant effect was seen on the 'Relaxation' dimension suggesting, as the previously presented results have, that this is the principal measure for the response to the hospital soundscape. Natural sounds had a significant effect on perception of the soundscape causing a significant 10.1% positive change in the emotional-cognitive response. This was unsurprising given the findings urban soundscape work has produced (Yang & Kang, 2005; Guastavino, 2006), highlighting the benefit of natural soundscape elements.

Additionally, this was the only intervention to produce a consistent positive effect, shown by positive movement within the dimensional space towards the relaxed/comfortable end of the dimension. Tsuchiya et al., (2003) can be used to explain this. The authors found that natural sounds played to patients undergoing a general anaesthetic had a significant calming effect and, relevant to these results, also improved the perceived acceptability of the anaesthesia experience compared to patients who experience normal sound. Therefore, this reinforces the relaxing positive effect natural sounds can bring to an arguably stressful soundscape through an improved, more relaxed, emotional-cognitive response. Therefore, within the CT ward soundscape, natural sounds could benefit in improving the everyday experience of the ward environment.

Steady state sound produced a significant effect on the ‘Relaxation’ dimension although this was a considerably smaller 3.3% change in the emotional-cognitive response. However, the results reported non-significant differences between clips ratings in comparison to the existing soundscape. Some clips also showed a negative movement on the ‘Relaxation’ dimension although when using mean values then the effect was positive. Limited comments specifically mentioning this additional sound suggests that it did not evoke a conscious appraisal unlike natural sounds and therefore the benefit is more questionable. In comparison, Stanchina et al., (2005) looked at the influence of white noise on sleep in subjects exposed to ICU sound. Using 8 participants the authors found that when white noise was added to the sounds of ICU, despite an increase in sound level, at a subjective level, sleep was consolidated and arousal was less frequent. Despite a small sample and a non-significant effect coupled with the presented findings, there is a change in perception with steady state sound. Regarding sleep this may be positive, however, for the everyday environment the sound may be appraised as simply and additional occupational sound rather than adding a new positive component to the soundscape like natural sound.

6.4.2. Hypothesis 2

Hypothesis 2 stated; there would be a significant positive difference in the overall scores on the emotional-cognitive dimensions between the existing soundscape and cognitive intervention soundscape. The rationale at the start of the chapter suggested that this would alter the secondary dimension of soundscape perception. SSI proved to have a significant overall effect on the 'Relaxation' element of the soundscape. Encouragingly, this intervention produced a 4.7% change in response which was nearly half that of natural sound. Considering this effect caused by the intervention, some participants suggested they did not sense the benefit of having information; "*doesn't affect feeling*". Perhaps the effect of SSI may not be obvious to the individual as it is not perceptually tangible, unlike the addition of a sound, but may actually influence response nevertheless. The non-significant effect was seen on the 'Interest & Understanding' dimension was unexpected. It was thought SSI would facilitate understanding and therefore affect this secondary dimension of CT soundscape perception as well.

This result is comparable to the Williams & Irurita (2004). The authors examined the perception of therapeutic and non-therapeutic interaction across 40 patients. Although looking at human interactions there are some comparisons to be made with these results. They identified emotional comfort in patients specifically associated with the feelings of the person. This was defined as a pleasant positive feeling and a state of relaxation of which personal control was a central feature. Here, information was designed as a coping aid for individuals to psychologically deal with the soundscape through understanding. Therefore, it can be suggested this has the potential to aid this sense of personal control thus, facilitating the emotional comfort highlighted by Williams & Irurita, (2004). Potentially this could be a reason why ‘Relaxation’ was facilitated.

Notably, not all the clips showed a positive movement towards ‘Relaxation’. Therefore, the benefit of SSI may be dependent on other factors needing exploration, especially as no previous soundscape work has looked at the effect of SSI has on perception. However, based on the results taken as a whole, it can be said that the overriding effect based on the results and subjective comments was positive with no effect on ‘Interest & Understanding’.

6.4.3. General comments

When considering the response to the individual sound clips, comparing the control condition vs. interventions, only two reached significance. This was surprising as it was thought that each intervention may produce more of an effect. However, when considering the small effect that was reported (partial $\eta^2 = 0.05$) this is not surprising. Moreover, it must be remembered that using ANOVA as an analysis method merely considers the difference between means rather than the specific values. Both clips 4 and 12 recorded a positive significant difference ($p = <0.05$) for NS vs. Control. Exploring this, SPL appeared not to influence positive perception as clip 12 was rated more positively than clip 4 despite it having a higher SPL (68.75dB(A) vs. 64.67dB(A)). It is noteworthy that clip 12 was rated more positively across all conditions compared to clip 4 despite this higher level supporting the view that although important, SPL does not determine perception. Clip 12 contained the sounds of a nurses talking and laughing with occupational sounds present. Clip 4 contains background occupational and monitor sounds. It should be expected that clip 4 would be rated more positively, yet as the nurse conversation was not medical participants may have found this more relaxing than just the ambient soundscape. If a patient demographic had been used to rate the sound clips this may have been different as some patients commented that staff conversation could be positive, whilst others saw it as negative:

> *P: I don't know the names of the patients I don't even know what they look like but never the less, if I was interested I would know quite a lot about their medical progress. I know what all the nurses are doing at any one time because it's all being reported and I know where people have been on holiday. Um, so because it's almost on a public thoroughfare [the patient's private room] it seemed quite reasonable for people to talk their chit chat. Whether its medical chit chat or just trivia, right outside my door, which is very, um disturbing - can't rest.*

In comparison, clip 6 containing the sound people talking, footsteps and the intermittent sound of a patient screaming produced the most negative response yet did not record a significant difference across any of the conditions. Therefore, when a dominant negative sound is present, an intervention may not be effective in preventing a negative response. Moreover, this was the sound that in the interviews a patient described as *"upsetting"* supporting the findings here. It is of interest to note that SSI did not produce the most positive effect. This can be attributed to the SSI failing to target these specific concerns.

6.4.4. Sound level and the emotional-cognitive response

The premise at the start of the project was that perception may be independent of SPL and therefore, sound level reduction may not be the most successful way to achieve a positive hospital soundscape. Correlation analysis revealed this with weak non-significant correlations between the emotional-cognitive response and SPL dB(A) of each clip. This is comparable to Hume & Ahtamad (2011) who found no relationship between urban sound clip level, subjective rating and any physiological measures (HR, RR, EMG). This begins to show that perception and response to clips was dependent on content, something that objective analysis of hospital environments is missing. Indeed, this relationship is something that objective analysis of the sound levels in hospital has failed to specifically look at. The positive association with quiet time from the interview data showed that occupational sounds were most negative, as control of these made the environment seem '*calmer*' although this did also significantly reduce sound level. In this study, when background occupational sounds were present, with no dominant foreground sounds, these clips on some occasions were rated more positively concurring with the interview data. Figure 29 visually explores this relationship and shows that dominant foreground hospital sounds generally create a more negative, stressed, reaction when compared to the background ambient hospital soundscape.

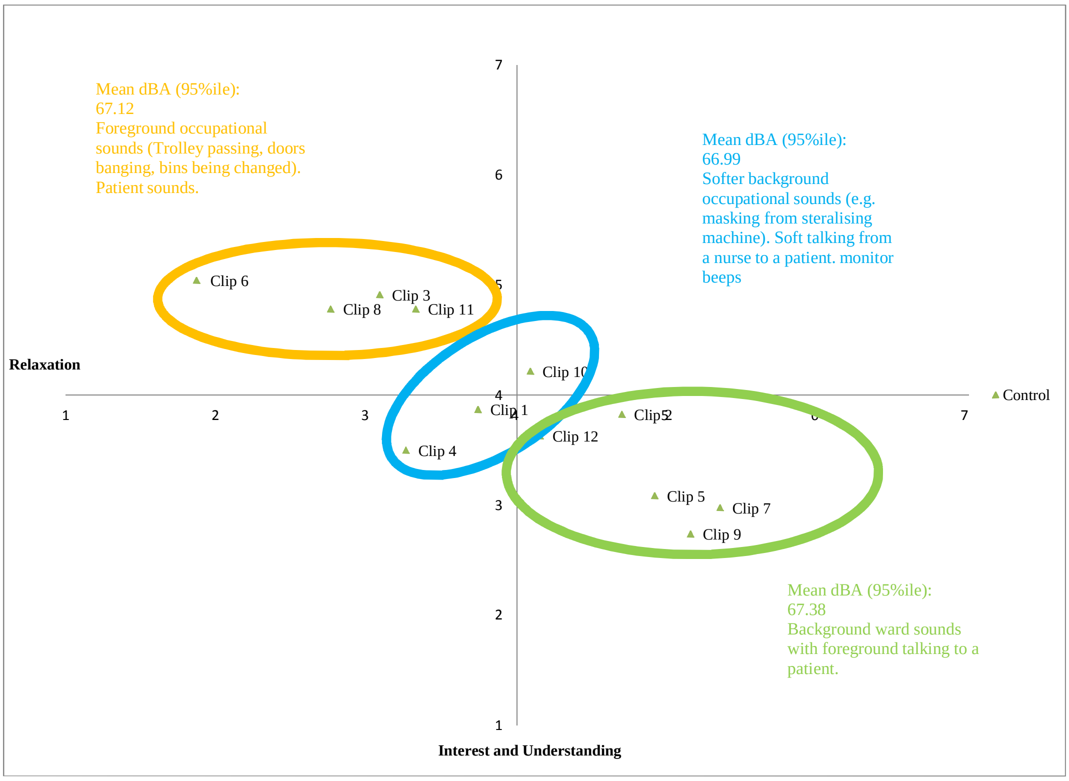

Figure 29. Showing the response to each of the sound clips which are grouped by content in condition A the existing CT soundscape. *Note*, foreground occupational sounds more commonly perceived as negative on the ‘Relaxation’ dimension but mean SPL varies across cohorts.

6.4.5. Soundscape interventions and the conceptual model of soundscape perception

The findings can be related back to concepts within the conceptual model (Figure 30). The results promote NS and SSI as the strongest effect on the response to the soundscape, although it must be acknowledged that the overall effect represented a small 5% change in emotional-cognitive response. NS potentially provide a sense of restoration from the soundscape, as they provide an association away from the hospital soundscape and a positively perceived sound. This may be the reason for the positive association and facilitation of ‘Relaxation’. SSI, although not significantly effecting the perception of individual clips, can be thought to facilitate the contextualisation and therefore understanding of sounds which, instead of altering the interest in the soundscape, facilitates ‘Relaxation’ to the sound. However, as no visual stimuli were presented to participants this result is based purely on hearing the sounds in isolation. The auditory visual congruence needs exploring as this may alter the emotional-cognitive response with this intervention.

Based on the findings of this study, NS and SSI potentially provided the most effective means of improving the perception of the soundscape. It is noteworthy that the addition of sounds to the environment was something that was met with mixed response by patients in the initial interview stages:

P: Additive sound is not on.

Therefore, any use of NS may have to be at set periods and in context meaning they would work most effectively if the sounds were matched to the surrounding environment, for example, the view of a green space. Although, the study was carried out in a laboratory with no visual cues, the auditory soundscape and visual landscape have the potential to influence the perception of tranquillity in a real multisensory environment (Pheasant et al., 2010) of which a hospital space is. Based on these findings however, SSI proved to be an easy and effective way to increase ‘Relaxation’ through aiding understanding and contextual awareness.

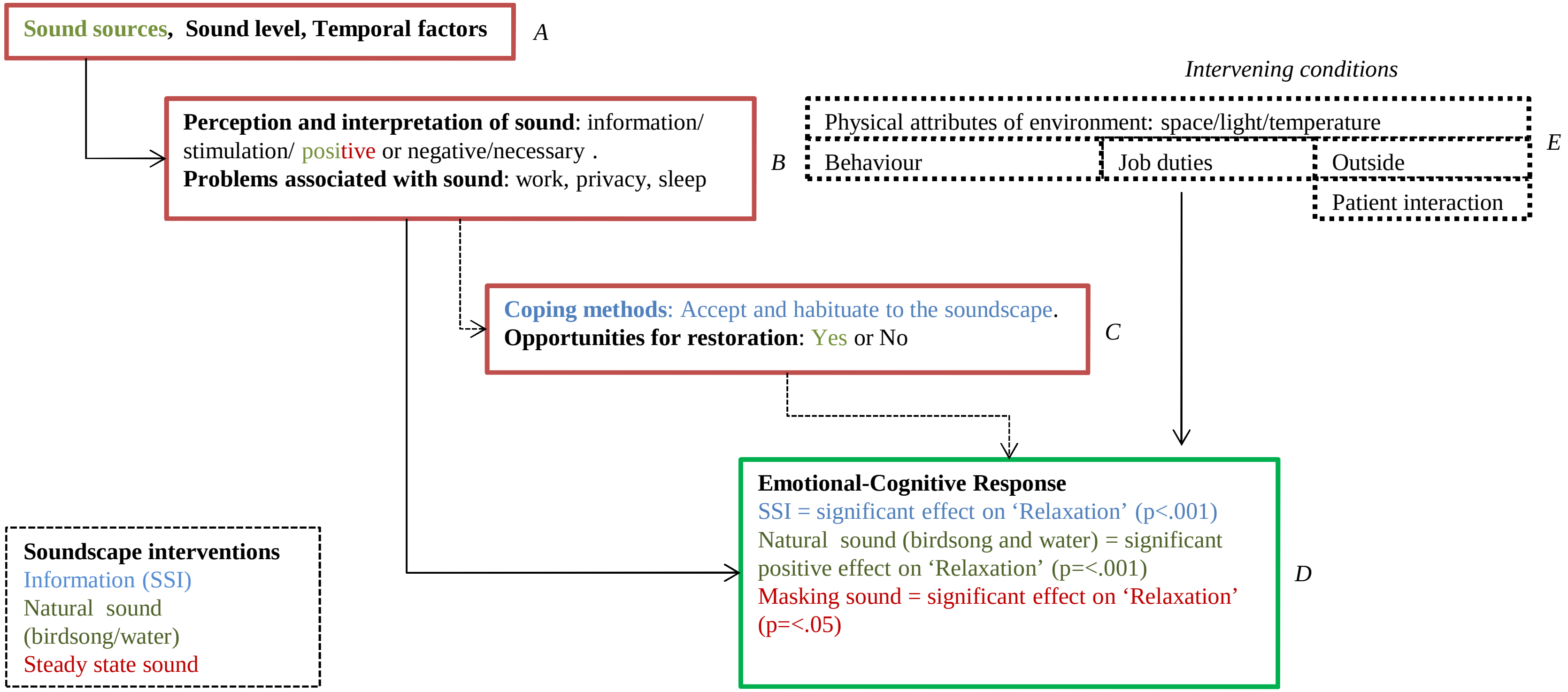

Figure 30. CT ward soundscape perception conceptual model with the key interventions highlighted.

6.4.6. Conclusions from study.

From the results it was concluded that natural sound produced the most positive influence on the response to the soundscape. However, from discussion and interpretation of the study SSI was explored further particularly as no previous research exists looking at how SSI effects the perception of a soundscape. Despite not always producing a positive response for each soundscape clip, SSI did create a significant positive main effect on the 'Relaxation' dimension. More importantly, this provided a feasible intervention which to test in-situ within the CT ward and tested the ecological validity of the intervention on a patient demographic.

The rationale behind this direction was provided by Ochsner & Gross (2005) who describe the neurological processes in the cognitive control of emotion. In it they suggest cognitive change might be used either to generate an emotional response when none is present or to regulate an already triggered response with use of working memory and/or learning. One aspect of cognitive change is reappraising and reinterpreting the meaning of a stimulus to change ones emotional response to it. Therefore, based on this theory this top down appraisal of the soundscape may be facilitated by using SSI to change and manage the emotional response to the soundscape thus facilitating coping methods of habituation and acceptance. This was investigated in study C2.

6.5. STUDY C2: INFORMATION AS AN IN-SITU SOUNDSCAPE INTERVENTION

The aim of this section of work was to carry out a scoping study to test the effect of SSI in-situ with theories of the cognitive control of emotion applied to any findings. The results in Study C1 helped formed the following hypothesis:

- H_0 = There will be no change in perception caused by SSI on the emotional-cognitive response to the soundscape.
- H_1 = SSI will create a change in perception on the 'Relaxation' element of the emotional-cognitive dimensions.

H_1 was two tailed due to the slightly unclear result from the listening evaluation described above.

6.6. Method

6.6.1. Procedure

The study used two questionnaires which were assigned to participants randomly. The first questionnaire was used as a control and contained solely the rating scales measuring the emotional-cognitive response to the soundscape (Appendix 5.1.). The 'intervention' questionnaire contained the same rating scales with the addition of SSI and associated activities (Appendix 5.2.). The rating scales remained unchanged despite some limitations, discussed later in the chapter, to allow direct comparisons with the listening evaluation. The use of the semantic scales was supported by the relatively high reliability recorded in Study C1.

Suitable participants were identified with consultation by the ward manager. Each received an information sheet and consent form along with the questionnaire

(Appendix 5.3.). Participants were asked to read the study information sheet and sign the consent form in their own time. When the questionnaire was distributed, a verbal description of the task and topic was given by the researcher to aid comprehension. Participants were then given 5 days to complete the questionnaire which was rated three times a day, 9am, 12 noon ,and 4pm, based on the question *how does the soundscape make you feel?* The term soundscape was defined in the information sheet. At the end of the questionnaire demographic information along with questions regarding the soundscape and thoughts on the effect of information were asked (Appendix 5.1 and 5.2).

6.6.2. Sample

Due to the nature of the CT ward, many patients were too ill to be approached for participation. In total 31 participants were recruited over a 10 week period (table 22). The questionnaire response rate from the participants was 51.6%, corresponding an even split of 8 participants in each group. Those that returned the questionnaire did not always complete it in its entirety as some stopped at different stages due to operation or being discharged, resulting in missing data.

Sample size (n) and demographic	**Mean age, years (S.D)**
Control = 15 (male =7 / female =8)	68.7 (9.9)
Intervention = 16 (male =11 / female =5)	

Table 22. Sample characteristics.

No formal sample size calculation was made due to the scoping nature. For reference, a full study sample size was calculated using GPower3 software (Faul et al., 2007). Setting a power level of .80 with an effect size (eta2) of 0.30 for analysis with a non-parametric Mann Whitney U test of analysis, 290 participants would be required

(145 in each group) with a 95%CI and test power of 0.80. Due to the time constraints and pragmatic issues of in-situ hospital based research this was not feasible.

6.6.3. Analysis

The non-parametric Mann Whitney U test was carried out on the data due to the limited data available and number of missing data points[3]. The aim of the analysis was to look for patterns in the data rather than draw strong conclusive inferences from it. The analysis looked for significant differences in the mean ranks of the conditions (Dancy & Reidy, 2007, p,533). Again, data was analysed using SPSS 19.

6.7. Results[4]

6.7.1. Normality of data and scale reliability

Normality testing revealed the data to be reasonable normal within the calculated parameters (Appendix 5.4.). The semantic scales showed an acceptable level of reliability (table 23) with only 'Interest & Understanding' on the intervention questionnaire producing moderate reliability, Cronbach's α = .588.

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[3] For reference the control group recorded 51 units of data whereas the intervention group recorded 49 units of data on which the analysis was performed.

[4] All analysis was based using the combined scores for each dimension unless stated otherwise, that is, Relaxation was measured using the scores of both stressed-relaxed and comfortable-uncomfortable; Interest and Understanding using curious-uninterested and intrigued-bored.

Reliability Statistics Relaxation control group	**Reliability Statistics Interest & Understanding control group**
Cronbach's α	Cronbach's α
.769	.726
Reliability Statistics Relaxation information group	**Reliability Statistics Interest & Understanding information group**
Cronbach's α	Cronbach's α
.740	.588

Table 23. Reliability testing results.

6.7.2. Main effect

The Mann Whitney U test (table 24) revealed a non-significant difference between the control and SSI scores on the 'Relaxation' dimension across all time periods; 9am (U = 857.5, N_1 = 43, N_2 = 45, p = .35, r = .10); 12 noon (U = 1105, N_1 = 46, N_2 = 49, p = .87, r = .02); 4pm (U = 958.5, N_1 = 44, N_2 = 44, p = .80, r = .03).

On the 'Interest & Understanding' dimension a significant difference was recorded across all time periods; 9am (U = 667.5, N_1 = 43, N_2 = 46, p = .007, r = -.28); 12 noon (U = 804.5, N_1 = 46, N_2 = 50, p = .010, r = -.26); 4pm (U = 614, N_1 = 44, N_2= 44, p = .003, r = -.32). Considering the result, here the effect was small to medium which is encouraging given the reduced sample size and missing data. Therefore, SSI may increase the understanding towards to the soundscape measured by the increase in uninterested/bored response. The results are plotted on the perceptual space (Figure 31) depicting the variation in perception SSI caused. This effect represents a 21-26% change in emotional-cognitive response (table 24).

Emotional-Cognitive response and time	**Control group mean**	**Information group mean**	**P-value** ***(95% CI=.05)***	**Percentage (%) change (information vs. control)**	**Effect size r (r =z/√n)**
Interest & Understanding 9am	4.60	3.65	0.007*	-26.08	-0.28**
Interest & Understanding 12 noon	4.39	3.62	0.010*	-21.31	-0.26**
Interest & Understanding 4pm	4.73	3.84	0.003*	-23.08	-0.32***
Relaxation 9am	4.65	4.29	0.350	-8.45	-0.10
Relaxation 12 noon	4.83	4.73	0.870	-1.93	-0.02
Relaxation 4pm	4.89	4.59	0.800	-6.44	-0.03

Table 24. Summary of results including percentage change in scores and effect size. *Note,* *denotes significant result at p=<.05; **small effect size; ***medium effect size.

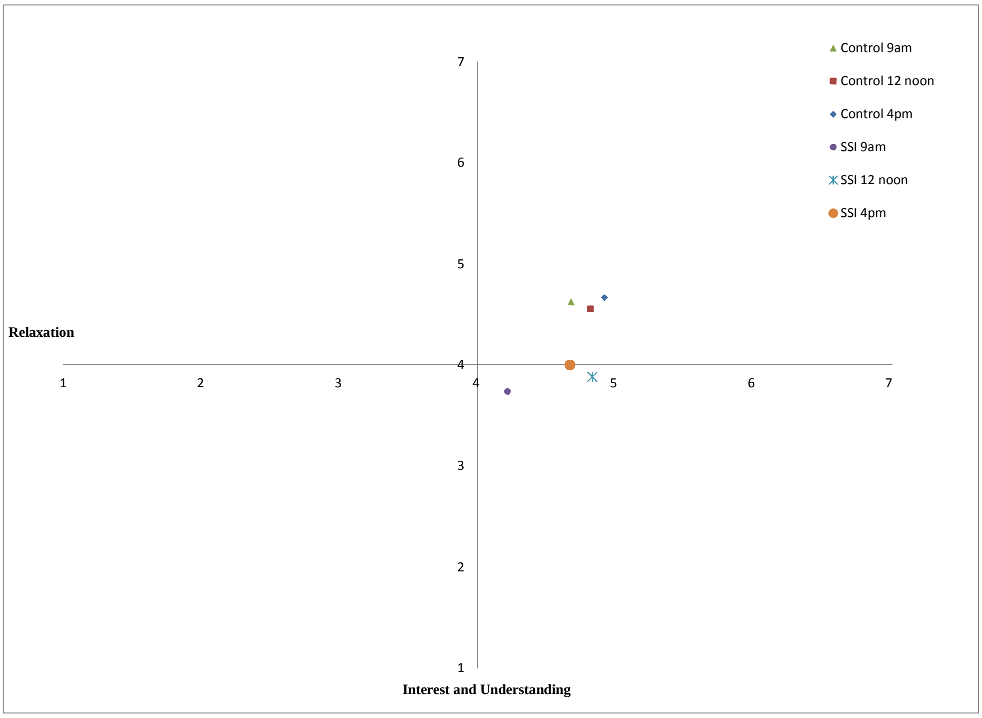

Figure 31. Mean scores for each dimensions at each time plotted in the two dimensional semantic space. *Note,* significant differences seen on the 'Interest & Understanding' dimension.

6.7.3. Subjective data

The most important question at the end of the questionnaire was:

How does/would having information about the soundscape make you feel?

Not all participants answered the questions. Those who did suggest mixed feelings. Three participants who received SSI made the comments:

No great feeling.

Doesn't bother me at all.

Negative.

One participant who received the control questionnaire remarked that SSI would make them feel "*worried and anxious*".

6.8. Discussion of results

The scoping nature of the study means that it is not possible to make strong inferences from the results. However, the analysis showed that SSI, when applied to a patient demographic, effects mostly the 'Interest & Understanding' dimensions of perception (p = <.05, r = .26-.31) across all time periods during the study. The percentage change in the 'Interest & Understanding' element of the emotional-cognitive response was around 21-26% and represents a small to medium significant effect. This adds further support that SSI causes the patient becoming more uninterested/bored and therefore possibly describing a certain level of habituation and acceptance to the soundscape through understanding. This is reverse to what was found in the listening evaluation and sits more closely with the original hypothesis that the effect of SSI would act on the secondary dimension of perception.

A consideration in interpreting the results was duration the patient was in the ward. Generally participants were recruited when they were first admitted. Therefore, their knowledge of the sounds will increase with time and therefore lead to a change in perception, which SSI possibly facilitated more quickly. Further data would be needed to be collected to explore this relationship and analysed using regression to show predicted and actual trends.

SSI did not significantly affect the ‘Relaxation’ towards the soundscape. Indeed, the results of the control and intervention questionnaire showed that ‘Relaxation’ is relatively high within the ward (see Figure 31) especially when compared to the listening evaluations. There is one possible explanation for this. When consistently exposed to the soundscape the response appeared more positive than when exposed to short sound clips, as in the listening evaluations. At a quantitative level, this suggests that the benefit of SSI is potentially useful. However, the subjective remarks obtained from patients propose that the benefit of information created no strong feelings with one comment, “*negative*”. Indeed, no positive comments were obtained regarding this. As sounds are perceived in the environmental context, the effect of SSI may change as there is visual auditory concurrence of stimuli. The presence of other stimuli visual and social, create a coherent environment and therefore the sense of ‘Relaxation’ may be higher than when the CT soundscape stimulus is presented on its own. Indeed, Pheasant et al., (2010) found that the tranquillity assessment of a landscape made in response to a uni-modal stimulus, the soundscape, can become modified in the presence of bi-modal information such as visual stimuli. Therefore, the contextualisation reported in the listening evaluation was pronounced, as the sound sources could not been seen which

SSI facilitated. Thus, when applied in situ, SSI appeared not to provide this added benefit thus, not enhancing ‘Relaxation’.

This suggests that SSI has an effect but is unclear if this is largely positive. The ambiguity here has two possible causes. The first stems from the scale meaning on the ‘Interest & Understanding’ dimension, shown by the reduced constancy of the scales. Additionally a more theoretical explanation is considered. Potentially, novel or unusual sounds, such as a patient screaming, need to be understood more than the regular everyday ward soundscape. This would facilitate understanding and therefore ‘Relaxation’ more greatly.

The control of emotion can be used to explain this. Folkman & Lazarus (1988) suggest that when a person is in an environment the interaction is appraised, generating an emotion. This influences the coping processes, which can be either problem focused, often used in situations where something can be done (Folkman, 2008), or in the case of the soundscape, emotion focused - used in situations that have to be accepted. After coping, the situation is then reappraised leading to, potentially, a change in emotional intensity (Figure 32).

Relating this to the findings here, having SSI participants were reminded of the hospital context, and indeed the sounds, thereby failing to elicit an increase in ‘Relaxation’. Importantly, a high mean age was reported by Folkman & Lazarus, (1988) of 61 years comparable here. SSI of the soundscape may have a different effect when sampled on a younger age range - such as the listening evaluation demographic.

This is a tentative suggestion and interpretation of the findings, but the concepts of Folkman & Lazarus (1988) can be integrated to the conceptual model (Figure 32). It is now possible to map the response to the soundscape using SSI as an intervention in a theoretical manner to see where SSI acts to change the perception of the soundscape. Additionally, this helps validate the model in terms of its theoretical credibility.

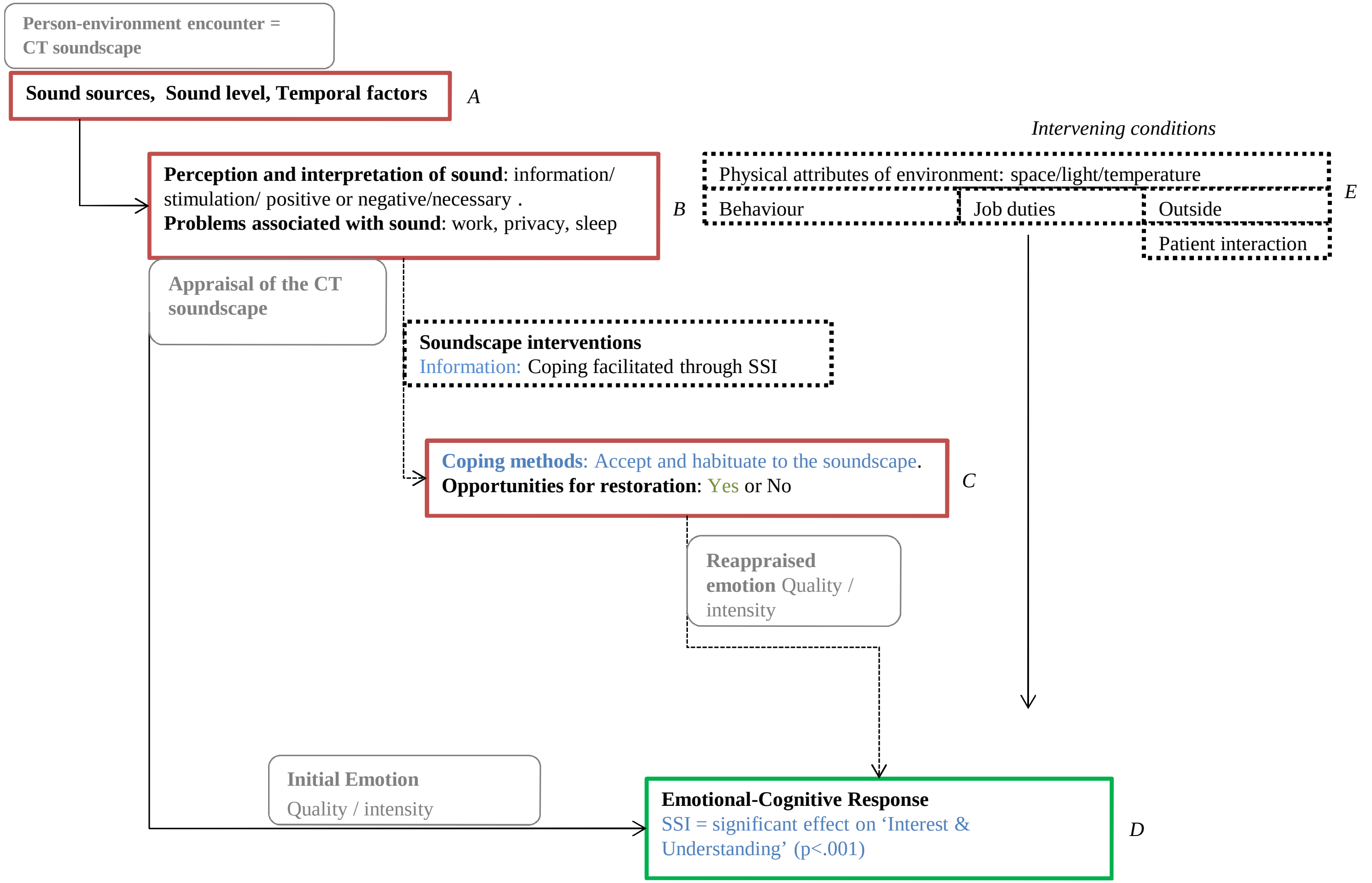

Figure 32. Conceptual model depicting the response to the CT soundscape using information as an intervention in relation to coping as a mediator of emotion theory from Folkman & Lazarus (1988).

6.9. Limitations

The following limitations are acknowledged in each of the studies.

Study C1 listening evaluation:

- The scales, although developed through previous experimentation, may provide some limitations as not all the emotional response associated with each dimension may be expressed. One participant suggested a calm-agitated scale would have been more appropriate although no other participants commented on potential limitations of the scales.
- The study used a priori design. As such the results were analysed using the statistical methods chosen prior to data collection in order to power the study appropriately and calculate sample size. Arguably multivariate analysis of variance (MANOVA) may have meant the analysis was more powerful. Indeed, Field (2009, p, 462) cites Stevens (2002) that when sphericity is violated and sample size (n) = a+10 (a=number of repeated measure) then multivariate procedures are more powerful. However, the power of multivariate tests varies in relation to the correlation between dependent variables (Field, 2009, p, 462). As the 'Relaxation' and 'Interest & Understanding' dimensions were orthogonally related then ANOVA may be justifiably used as the one of the assumptions of MANOVA is that the dependent variables have to be reasonably correlated.
- The sample selected was predominantly from the University community with a low mean age. This is not representative of a patient demographic within a CT

ward. As such, the ecological validity of the findings may be limited although this was somewhat addressed in study B.

- It was decided that no visual cues would be provided in the laboratory testing to ensure that responses were made solely in response to the sounds participants were presented with. One participant commented that visual recognition of the sounds would influence feeling. Indeed, this may be the case as context is important in soundscape perception (Brown et al., 2011) and as such this is acknowledged as a limitation.

Study C2 had a number of limitations:

- Firstly the sample size was small meaning that strong inferences could not be made. Missing data also contributes to this.
- Another limitation was the lack of control as to when participants completed the questionnaire. Each participant was left to complete the questionnaire on their own. Moreover, there was no guarantee that the questionnaires would be completed at the correct times. This limits the validity and reliability of the results which can only be overcome by obtaining a large sample size with a more robust experimental procedure. It should be remembered this was a pilot study and was designed to require little interaction with patients and to be largely self-administered. Importantly the study assisted in the developing the theoretical underpinnings of the conceptual model and allows new avenues of work to be explored.
- The study only considered the use of situational information about the sounds sources due to the simplicity of it. This has shown to have an effect. However,

emotional and sensory information as used in Baum et al., (1981) should also be considered. This may provide benefits or disadvantages which need exploring.

6.10. Conclusions from Chapter 6

To summarise, the listening evaluation showed that physical interventions have a significant effect on altering the emotional-cognitive response to the CT soundscape. Importantly, natural sounds and SSI were shown to affect these significantly. Most encouragingly, when tested in-situ, SSI affects the emotional-cognitive response to the soundscape in what can be interpreted in a positive way. In order to produce more robust findings the ‘Interest & Understanding’ dimension scales require further development to ensure that the semantic scales can be understood and results be clearly interpreted. Now there is a theoretical underpinning to this SSI intervention which related to the conceptual model of hospital ward soundscape perception, further work can be used to tackle and explore the theoretical rationale and limitations expressed here.

CHAPTER 7

GENERAL DISCUSSION

7.0. Introduction

This chapter discusses the results and value of them in relation to the objectives of understanding the perception of a hospital ward soundscape, defining and creating a measurement tool and finally testing soundscape interventions. This is then used to generalise the findings beyond the CT ward to show the potential benefit of the research along with the boundaries of it. The overall limitations of the project are given along with potential future work and application of it.

7.1. Reflection on results

7.1.1. Study A1

The first objective was to understand the perception of the soundscape at a qualitative level. This took the phenomenological stance first hand and clarified the experience of the soundscape from both patients and nurses. This approach was successful as the analysis yielded a conceptual model of the hospital ward soundscape perception thereby allowing this experience to be mapped in relation to the feeling it elicited. This became the foundation for the subsequent work, showing the value of this approach. Perhaps most importantly, coping methods emerged from the data which acknowledge the fact that both groups are affected by the soundscape. Specifically, coping strategy of acceptance and habituation were the prominent concepts which related to the role of understanding the soundscape and supported by Davies et al., (2013). These were in a sense a cognitive control of emotion strategies put forward by Folkman & Lazarus (1988) and Folkman (2008). Indeed, cognitive processes begin with sensation and perception (Herrmann et al., 2006) which the soundscape provided. Importantly, information and understanding were drivers for this and it appeared that the patients who were able to adopt these were more comfortable in the environment as a result.

Additionally to this coping method, the view of green space and associated sounds proved to have a somewhat restorative and positive element to them. Perhaps this was unsurprising given that soundscape research acknowledges the benefit of such sound in increasing pleasantness to sounds such as traffic (De Coensel et al., 2011, Jennings & Cain, 2012). Furthermore, the biophilia hypothesis promotes the benefit the association of nature has for most individuals, be it through visual or auditory stimuli (Grinde & Patil, 2009). Therefore, addition of 'nature' to these sterile environments may enhance this further. Based on the interpretation of perception from the conceptual model a strong rationale was developed to explore soundscape interventions to facilitate coping methods to influencing the response to the soundscape.

7.1.2. Study A2

The objective data obtained from the sound recordings was useful in providing a point of reference against other research and allowed, as Cain et al., (2011) promotes, to look for the connects and disconnects between the quantitative and qualitative aspects of a soundscape. Generally, only the SPL attributes of a hospital ward are reported in research as these correspond to the WHO guidelines. Encouragingly, the analysis of the 28 sound recordings found the mean SPL dB(A) of the CT ward to be 64.17dB(A) and 62.28dB(A) in the corridor and bay areas respectively. Thus, these concur with recent studies (Akansel & Kaymakci 2008; Pope, 2010; Juang et al., 2010) all of which report SPLs between 60-70dB(A) within hospital ward environments. This therefore, supported the validity of using the CT ward as a setting to gain an understanding of the perception to a hospital ward soundscape.

Further assessment of these attributes showed that ‘quiet time’ had a significant effect on lowering SPL and loudness in the ward. This is comparable to Gardner et al’s., (2009) robust study of a quiet time which substantiates the presented findings. This controlled occupational sounds within the ward suggesting these contribute mostly to SPL, as well as a dominant sound source component. When linked to the interview data, occupational sounds can be said to be perceived as most negative as controlling these created a “*recharging*” sense – a more positive response from the soundscape. This is not surprising as Rice (2003) reported that hushed voices and hospital trolley squeaks became oppressive.

Coding of the sound sources using the method by Poxon et al., (2009) supported Selbien & Skelton’s (2009) view that hospital sounds can be broadly grouped as occupational, human, medical equipment, and sounds from outside. Most importantly, triangulation of the objective and qualitative analysis showed that human and occupational sounds may be the key component in determining whether a healthcare ward soundscape is perceived positively. ‘Quiet time’ reflected this as it removed the more unnecessary sounds, which resulted in the subjective response to the soundscape was improved. Aiding understanding and acceptance of the sounds developed as potentially effective avenue to promote positive feeling along with natural sounds:

> *P: I don’t mind when it’s noisy as long as there is a reason for the bloody noise.*

7.1.3. Study B1 and B2

In order to investigate the potential interventions developed from the conceptual model, a perceptual space needed to be made. A gap exists to rigorously assess deliberate soundscape interventions to understand what design aspects do and do not work and a perceptual space is one way to do so (Cain et al., 2013).

Firstly, the semantic validation successfully obtained language that described how the individuals felt as a result of hearing the CT ward soundscape. Most importantly, this matched the language obtained from the interview data, which went some way to validate the listening evaluation environment and the convenience sampling method. This also increased the breadth and diversity of language used to represent the evoked feelings.

‘Calm’ was the most frequently observed positive word with ‘annoyed’ being the most negative. The word ‘Calm’ was surprising as it was not thought a hospital soundscape would elicit such a feeling. Considering reasons for this, it can be postulated that as participants were aware of the notion of hospital sounds they expected to feel negative. However, upon hearing soundscape clip that contained background sounds with no dominant foreground features participants may have been surprised at the content of the clip and as such felt a sense of calmness. Indeed, a certain expectation may already exist that the sounds in a hospital are negative – ‘stressing’, ‘annoying’, which was shown through the language. Perhaps these preconceptions are why the language of the two data sources matched. We, as a society, are exposed to hospitals as a negative environment thus, any negative reaction may already be predetermined whereas a positive reaction may be more unexpected as shown through words such as ‘calm’, ‘relaxed’, ‘comfortable’.

These feelings were arranged into bipolar semantic scales and defined an emotional-cognitive response to the CT ward soundscape. PCA extracted this response to the soundscape which was described by two dimensions: ‘Relaxation’ and ‘Interest & Understanding’. These represented 56.8% and 13.4% of the variance respectively and therefore the element of ‘Relaxation’ was the dominant feeling. This ‘Relaxation’ element of the soundscape was defined by the scales relaxed-stressed and comfortable-uncomfortable. The second dimension represented a cognitive response, relating to how the individual interprets the sounds. This was interesting as such notions tied to the interview data from patients in that some sounds are accepted when they are understood. This ‘Interest & Understanding’ dimension was measured by the scales curious-apathetic and intrigued-bored.

The reliability of the scale in measuring these responses proved mixed. ‘Relaxation’ showed high internal consistency (Cronbach’s α= .961) whereas ‘Interest & Understanding’ showed only reasonable levels of consistency (Cronbach’s α= .693). This is possibly because the semantics of this secondary dimension lacked the clarity of the first. For instance, the terms ‘apathetic’ and ‘bored’ perhaps did not relate enough to a clear feeling which produced a certain degree of ambiguity for participants when rating these feelings. However, ‘curious’ and ‘intrigue’ clearly relate to an interested feeling which anchors one pole of the scale. As a result replacement of the word ‘apathetic’ with ‘uninterested’ was used to improve the clarity of this dimension. This successfully improved the reliability of the dimension during soundscape intervention testing.

The perceptual space proved to be successful in representing the response of the soundscape and discriminating positive and negative features of it. This initial assessment was to assess the features of the soundscape and to being interpretation of positive and negative sounds. Importantly it showed that the most stressed responses also seemed to produce the most curious suggesting that stressing sounds need to be understood to move perception to ‘Relaxation’. This linked to the coping theories of Folkman & Lazarus (1988) derived from the interviews. Therefore, aiding cognitive coping was identified as a new way to improve soundscape perception and aid ‘Relaxation’.

7.1.4. Study C1

The work culminated to consider interventions that may improve the emotional-cognitive response to the CT soundscape. At this point the focus of the project moved to consider the soundscape from purely a patient perspective. This was for two reasons. Firstly, the potential for getting healthcare workers involved in the research proved challenging which resulted in extended recruitment periods and a limited sample from the group. Secondly, patients are the focus of such spaces, and it is their recovery which is the key aim of the healthcare system. As stated by the Department of Health (2009) all should be involved in the development of the NHS. Therefore, as Ulrich (1992) states, these spaces need to be a supportive environment thereby justifying the focus on this group.

Both the physical and cognitive interventions related to the conceptual model, again highlighting the benefit the qualitative element of the work had. The emotional-cognitive responses were reliably measured by the corresponding rating scales. The adjustment of the curious-apathetic scale to curious-uninterested increased the internal consistency in the ‘Interest & Understanding’ dimension; $\alpha = .890$. This was important as it meant that the interpretation of the scales was improved thus increasing the reliability of the findings.

Both hypothesis H_1 and H_2 were partially supported by the results with the magnitude of response significant different (p=.001) on the 'Relaxation' dimension across all groups. The emotional-cognitive response to the 'Interest & Understanding' dimension was non-significantly affected by the interventions. This was interesting as the rationale behind SSI was that it would reduce curiosity to the soundscape and thus be more produce a significant effect on the secondary dimension. However, as the effect was small ($\eta^2 = 0.05$) on the 'Relaxation' dimension any effect on the 'Interest' dimension would needed to be increasingly large to produce a significant effect, especially when considering the variance it accounted for in the PCA, was only 13.4%.

Despite the fact demand effects were controlled for, these may have influenced the results. Participants were exposed to the same sounds four times, albeit on different occasions. As such the general response to the sound may have been remembered shown by the consistent trends in response to each clip depicted in the perceptual space. This may also be a reason for the recorded effect size being small.

7.1.4.1. Natural sounds as a soundscape intervention

Considering each intervention independently, natural sounds produced the clearest significant (p=.001) overall positive effect on 'Relaxation' corresponding to a 10.1% positive change in response. This was supported by the emotional-cognitive response to each clip moving towards 'Relaxation'. This intervention had two components as it contained the sounds of a blackbird's birdsong and a babbling stream. In hindsight, just use of just birdsong would have been favourable as this was representative of the sounds within the ward soundscape, that is, sounds from outside. However, due to the positive association of birdsong from research (De

Coensel et al., 2011) and the theory of biophilia, then it can be suggested that the results would not have changed significantly.

7.1.4.2. Steady state sound and Sound source information

Both steady state white noise and SSI produced a significant overall effect in 'Relaxation' but each clip did not respond consistently positively moving towards 'Relaxation' and accounted for only a 3.3% positive response. Steady state noise was not designed to produce a masking effect, just a consistent congruent background addition. As such, it perhaps did not have the positive connotations found in natural sounds.

Likewise SSI had this similar effect of producing a mixed response on the 'Relaxation' dimension. From the subjective comments, gathered at the end of the rating questionnaires, participants suggested that this aided contextualisation of the soundscape. This may be a reason for the 4.7% change in response. Potentially, in the listening evaluation context, SSI enabled participants to imagine the environment better thus eliciting a significant effect in their emotional-cognitive response, particularly 'Relaxation'. As stated, the premise behind SSI was it would aid understanding thus producing a more 'uninterested' response.

7.1.4.3. Sound level and perceptual response

Dubios et al (2006) wrote that the physical properties of sound must be used to point towards the cues of these cognitive objects which the objective analysis acknowledged. One of the objectives of the project was to demonstrate that sound level was not the only contributing factor in creating a positive hospital soundscape. This was analysed using a Spearman's rho correlation analysis which revealed no significant correlation between SPL dB(A) of the sound clips and the emotional-cognitive response. This therefore, goes someway to suggest that it is the content of sound that is important rather than physical level with the studies of Hume & Ahtamad (2011) and Bradley & Lang (2000) supporting this. Indeed, when considering the interventions, the addition of sound may have increased the SPL. Although this was not calculated, generally this did not affect the responses given to the clips in a negative way. Therefore, it is the content (sources and the understanding of them) which is fundamental in determining a positive perception to the hospital ward soundscape. Indeed, Yang & Kang (2005) suggest acoustic comfort has no relationship with sound level as it is a more complex phenomenon.

7.1.5. Study C2

Although convenience sampling was used for the listening evaluations, creating some bias and limitations, the final in-situ study used a patient demographic thereby relating the work back to this group. Despite the potential benefits adding natural sounds into the ward may have had, this was not taken further. As Snyder et al., (2012) state, auditory perception and cognition entails both low level and high level processes which are likely to interact with each other to create our conscious experience of soundscapes as such SSI offered the best means to manipulate perception. It should be remembered that the auditory systems primary function is to get information from the outside world into the brain where it can be used to plan future behaviour (Plack, 2005). This sensory information must be interpreted (understood) in order to give rise to a coherent perception (McAdams & Bigand, 1993) which SSI potentially facilitated.

This was a simple intervention that had benefits both pragmatically and academically. Considering the former, the intervention could be easily set up and did not have any of the ethical implications of taking equipment into the ward and playing sound. Additionally, this is a financially viable way to manipulate perception and one that could be implemented and made of real use within the NHS setting, linking to the cost effective work the King's Fund (2011) have done in the Enhancing Healing Environments programme. Most notably, SSI had not been previously tested as a means to manipulate soundscape perception despite the work of soundscape practitioners such as Hall et al., (2011) and Axelsson et al., (2011) stating information is a major component of soundscape perception. Therefore, this was an area of new academic merit when considering soundscape work particularly in these environments.

Testing SSI over three time periods in-situ showed the 'Interest & Understanding' response to be significant effected ($p = <.05$) across all periods in comparison to the control group with a small to medium effect ($r = 0.26$-0.32) found. This suggests that SSI results in the patient becoming more uninterested/bored representing a certain level of habituation or acceptance to the soundscape. Based on the interpretation of the scales, at a quantitative level this can be said to be a more positive response. Reduced curiosity means that the individual may be able to habituate to the sounds and thus, be stimulated in another activity if they wish. From the conceptual model of hospital ward soundscape perception and the results of the listening evaluation, was concluded this was positive because, highly interesting sounds were generally perceived negative when looking at the cohort trends in the data on the perceptual space.

Another notable finding was when compared to the listening evaluation 'Relaxation' was notably higher. This may be due to the acceptance/habituation towards the sounds, caused by fact that other stimuli were present such as nurses, talking, and treatment. All these elements affect perception by providing additional stimuli and contextualisation of the soundscape all of which facilitate understanding.

Therefore, high auditory visual congruence was present which was absent from the listening evaluations. This important as context effects are consistent with prior experience to a stimuli and therefore influence perception (Snyder et al., 2012). Additionally, the emotional-cognitive response from the listening evaluations may be elevated because when visual information is inadequate sound plays a more dominant role (Posner et al., 1976) thus influencing perception. Additionally, the array of sounds the participants were exposed to were unknown and therefore may not have been as broad as the specifically selected soundscape clips used in the listening evaluations.

The subjective comments regarding SSI showed that it could be negatively received and may increase anxiety from the soundscape. Using the cognitive appraisal model of Folkman & Lazarus (1988), this was theorised to be due to a cognitive reappraisal of the soundscape failing to reinforcing a positive feeling. Instead SSI may have supporting the initially appraised emotion and provided a reminder of the hospital soundscape. As the mean age was 68.9yrs this is comparable to the results Folkman & Lazarus (1988) who recorded 61.9yrs. Despite this, the result has given the potential for exciting future work. It should be remembered in the framework of soundscape perception proposed by Jennings & Cain (2013) that perception is dependent on demographic factors, activity, temporal variation, type of space and location. Yang & Kang (2005) found there was a significant difference in acoustic comfort ratings amongst different age groups for an urban setting. Consequently, the effect of SSI on a younger demographic needs investigation.

7.2. Application of the findings

Before continuing to discuss the broader application of these findings, it is important to note that these comments are in relation to patients within the hospital environment. However, the physical intervention of natural sound would have a beneficial effect for a nurse group based on the comments obtained during the initial interviews and the general theory as to why such sounds are perceived as positive.

7.2.1. The conceptual model of hospital ward soundscape perception.

The interview study allowed the development of a conceptual model depicting perception to the hospital ward soundscape. This is important as the tasks that confront us in everyday life vary in the demands on cognitive processes, including perception, learning and reasoning (Herrmann et al., 2006) all of which are pertinent in soundscape perception and the model to map this. As stated, this underpinned the following work which was used to expand the model to be inclusive of the soundscape interventions. Based on the collective findings, the context (the CT soundscape) and the theoretical interpretation of the results, this fully developed model is shown in Figure 33 and described below.

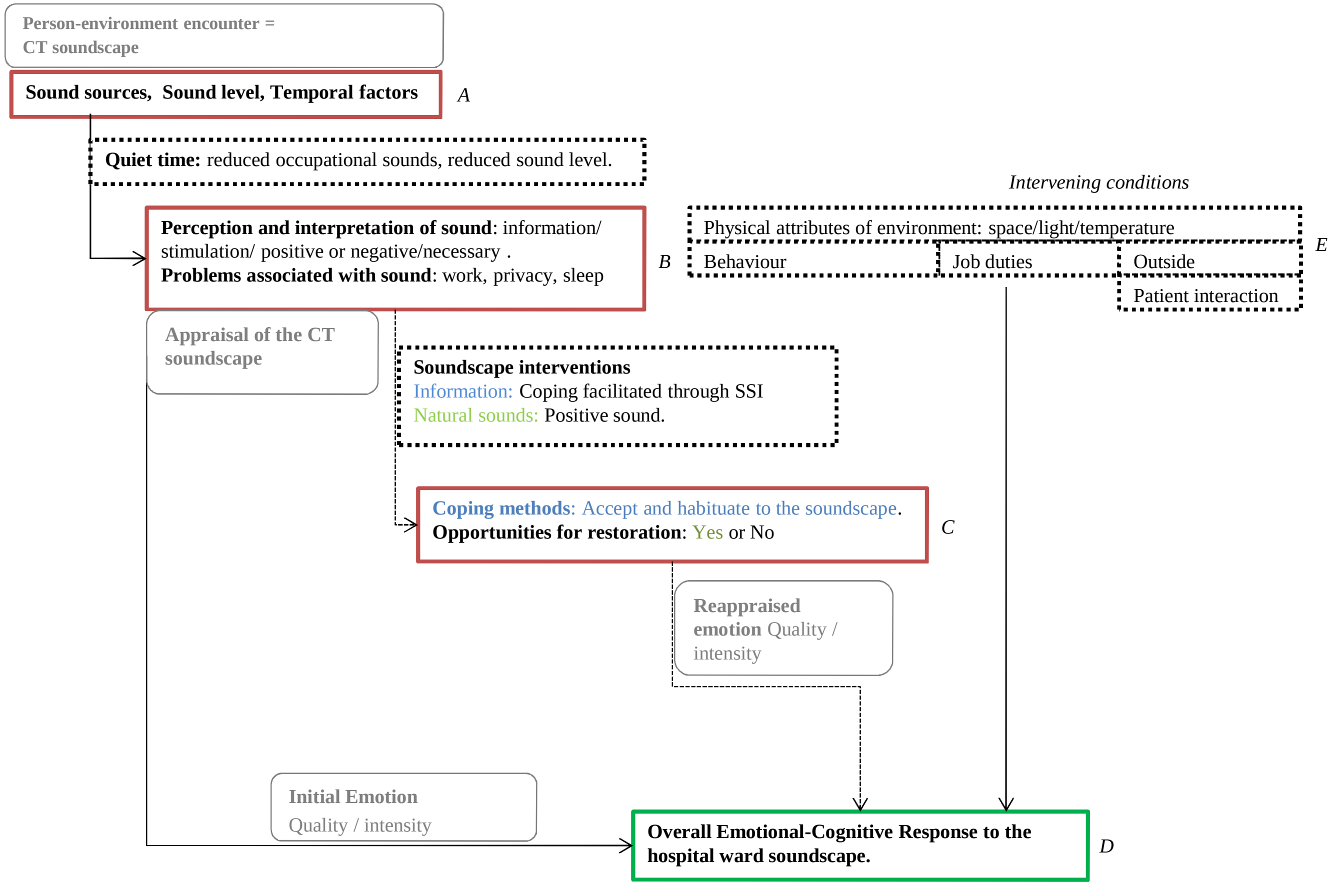

Figure 33. Fully developed conceptual model of hospital ward soundscape perception showing the various route of soundscape perception with the key junction point being the initial appraisal of the soundscape.

Firstly, in accordance with Folkman & Lazarus (1988), there is person environment encounter. In this case specifically, a soundscape-person encounter when within the hospital ward space. Specifically, this related to the sound sources, level, and temporal variation of the soundscape. Indeed, cognitive processes begin with sensation and perception (Herrmann et al., 2006) giving an appraisal of the soundscape, corresponding to an initial emotional-cognitive response – now defined as ‘Relaxation’ and ‘Interest & Understanding’. If the person develops a coping method of accepting or habituating to the soundscape, once the initial appraisal has been interpreted, this will be reinterpreted generating a reappraisal and a new emotional-cognitive response – generally more positive. Soundscape interventions can now be used to facilitate this, natural sounds, aiding ‘Relaxation’ and SSI possibly aiding habituation through reducing curiosity.

Additionally, ‘quiet time’ changes the temporal aspect of the soundscape. Therefore, the soundscape-person encounter produces a positive reappraisal thus an improved emotional-cognitive response. A soundscape can be considered positive if it enhances how a people feel about the place (Jennings & Cain, 2013) yet in the hospital environment a positive soundscape will come from an improved emotional and subjective response personal to the individual.

Figure 33 shows the perception and response to the soundscape from the perspective of patients. Importantly, it shows the various routes and theories that contribute to this response adding to the robustness of the model. The model can be used to highlight potential areas to consider in improving a ward soundscape, whether it is behaviour of individuals, SPL, sources, or simply modification of the daily routine. The model conceptualises various components of the soundscape, including physical, social, and perceptual attributes all of which can be considered individually or in an interaction. In some ways this is a more specific soundscape framework in comparison to Jennings & Cain (2013). Therefore, the model may be used as a tool to investigate these components, in relation to hospital ward soundscape perception. Potentially, this could be developed, in conjunction with the perceptual space, into use as an audit tool to assess a hospital ward soundscape.

The model could be applied to similar hospital ward environments due to the fact it was developed from a variety of participant groups, therefore increasing its validity. Many of the attributes within the model correspond to different hospital spaces. For instance, the sound sources and activities that create the soundscape are not specific to the CT environment as evident from the objective analysis and concurrence of with literature (Seibein & Skelton, 2009). This has yet to be tested, but the model could now be used to assess the soundscape of another ward and on a different patient demographic, for example, paediatrics.

The value of this is that perception of a hospital ward soundscape has never been depicted and explored in this way before. This can now be displayed in a relatively simple manner via the conceptual model and perceptual space. Importantly, this has integrated many theories from other disciplines, particularly psychology, to build a conclusive understanding that the hospital soundscape influences a person’s feeling. In addition, there are ways, beyond sound level reduction, to improve this. The central aim of the project was to understand the perception of a ward soundscape and how to improve it. Encouragingly, this has been achieved and depicted in the conceptual model of hospital ward soundscape perception.

To summarise, the model describes the perception to the soundscape. Simply, if the sounds of the ward can be accepted and habituated to, the soundscape is more likely produce an improved emotional-cognitive response. Foreground occupational or prominent dominant sounds contribute to a negative response. This is most applicable to patients with unknown and unfamiliar sounds perceived most negatively.

7.2.2. Application of the research: Natural sound birdsong.

To make this research of practical benefit, it was necessary to consider how these findings could be applied in the context of the CT ward. Testing various interventions showed that natural sounds provide the most consistent positive effect and facilitated the notion of ‘Relaxation’. Therefore this was the most positive intervention in terms of the emotional-cognitive response. This builds on existing evidence from research, such as Tsuchiya et al., (2003), that natural sounds can provide an additional asset to the healthcare environment and may benefit patients and nurses. Importantly, this focuses on the addition of sound rather than the removal as this produced a congruent background addition.

Based on this evidence, natural sounds offer an effective way of enhancing the sound quality of the healthcare environment. However, the subjective comments obtained from the interviews and listening evaluations need to be considered. Addition of any sound was remarked that it would be perceived negatively by patients. However, this intervention could be successful. Grinde & Patil (2009) concluded after the review of 50 empirical studies, that interacting with nature and the benefits of it on health and well-being are substantiated. Although considering the visual element of nature (for example, views of green space, plants) this can be applied here.

As auditory attention is drawn to sounds which have a mixture in temporal variation this lowers the amount of attention paid to other sounds (De Coensel et al., 2011). Therefore, the natural sounds, particularly birdsong, provide a distraction from the hospital sounds which has potential benefits. Furthermore, Gustavino (2006) found that sounds of other people, nature, birds were predominant categories for an ideal soundscape concurring with the positive addition of natural sounds.

Implementing this in a constructed manner, for example, sounds being played twice a day for a set period, offers a potential way for enhancing the perception of the hospital ward soundscape using this intervention. These times may facilitate ‘Relaxation’ for patients and give them a break from normal soundscape. For these set periods this ‘additional’ sound may be accepted. In support Jennings & Cain (2013) comment that it is widely acknowledge that certain individual sounds such as birdsong and running water are perceived to be pleasant however, pleasantness can only be judged in context. As a result, such an intervention requires further testing.

Although not investigated here, additional natural sound would have to fit the surrounding environment. For example, when overlooking a green space, natural sounds would have to match. In a sense, the aim would be to bring to sounds already existing outside, inside. In a hypothetical example, if a water feature was present along with birds singing in a green space then the natural sounds would have to achieve this and guarantee auditory visual congruence. As Pheasant et al., (2010) advocates bi-modal stimuli are essential for a full characterization of tranquil space, and that even when a soundscape is being characterized the visual scene is likely to be an important modifying factor in auditory perception. This would ensure acceptance and the positive effect of natural sound. Although this link was not within the scope of this research, it is an avenue for further work.

The addition of natural sounds to the ward soundscape has been tested under listening evaluation conditions, and therefore the ecological validity needs to be established. However, taking the results as they are, this offers a positive distraction helping to facilitate positive feeling and mood (Lauman et al., 2001) in the sensory deprived (Ulrich, 1992) healthcare environment. As one patient said:

P: It's gorgeous here because I have the birds.

7.2.3. Application of the research: 'Quiet time'

'Quiet time' can be acknowledged as having an important influence on perception. Although not experimentally tested it was something already implemented in the ward. Both staff and patients found the time very beneficial, shown by the positive comments from participants:

P: It allows you to relax.

P: Helps with the healing process.

N: Recharging time for us.

The analysis of the objective soundscape data showed that the SPL and loudness was significantly lower (p=<.05) during this period. Therefore, a combination of controlling sound sources (particularly occupational), in turn reduced the SPL. A more formal SPL evaluation procedure could confirm this further. Nevertheless, it has been shown that quiet time interventions have significant potential for improved patient outcomes and satisfaction, both of which are important in contemporary healthcare environments (Gardner et al., 2009). Therefore, based on the benefit of this period it can be put forward that this is a good way to positively influence the soundscape. Moreover, this adds temporal variation into the day which Mazer & Smith (1998) declare, along with the auditory environment, is part of the hospital experience.

7.2.4. Recommendations for ‘physical’ interventions

Recommendations from this research for a creating a positive healthcare soundscape using physical sound are as follows:

- The use of ‘quiet time’ via controlling occupational sounds. This significantly lowers the sound SPL and improves the subjective comments towards the soundscape during this time.
- The introduction of natural sounds using birdsong matched to the visual setting for set period during or when ‘quiet time’ is not possible.

7.2.5. Application of the research: Sound source information (SSI)

SSI proved to have a significant effect in both the listening evaluation and the in-situ study. The rationale behind the use of SSI came from the interpretation of the conceptual model and the cognitive control of emotion advocated by Oschner & Gross (2005), Folkman (2008) and which Davies et al., (2013) make notes of through cognitive coping in soundscape perception. Moreover, environmental features, such as the soundscape, help determine salient elements in an environment that cause people to learn, think, or remember in certain ways. Interpretation is necessary since the information contained in the stimuli that reach the sensory organs is not always sufficient to form a coherent image of the surrounding environment (McAdams & Bigand, 1993). Therefore, SSI aimed to fill this ‘gap’.

Furthermore, the goals of mental manipulation, in this instance SSI, is to improve accuracy and acuity of our evaluation or performance (Herrmann et al., 2006) to these spaces. As a result, this intervention was used as a coping mechanism by providing SSI to reduce curiosity and increase understanding of the soundscape. No previous research had used information in any form as a soundscape intervention despite much research, (Guillen & Lopez Barrio, 2007; Hall et al., 2011; Davies et al., 2013) acknowledging this as an aspect of soundscape perception. As mentioned before, Axelsson et al., (2010) state information is a major component in soundscape perception and importantly, soundscape are represented in memory on the basis of semantic features and their meaning, thus reflecting interactions between individuals and their environments (Guastavino, 2006) and the importance of the cognitive processes.

SSI proved successful in the listening evaluations as it created a significant main effect on the ‘Relaxation’ dimension (p=<.001) during the listening evaluation which was on the whole, positive. Furthermore, the positive comments related to ‘contextualisation’ of the soundscape. Interestingly, it appeared to have the reverse effect when tested in-situ, as a significant effect on the ‘Interest & Understanding’ was seen. This finding has limitations, due to the small sample size (n=31) and experimental control. Nevertheless, this suggests that, in the case of the CT ward, SSI may have facilitated habituation demonstrated the shift toward uninterested/bored axis of the perceptual space.

This result was interpreted in relation to Folkman & Lazarus’ (1988) work which found that younger participants (around 40 years) were more likely to positively reappraise a situation using a coping intervention. As such SSI may have a clearer positive effect on a younger demographic. To theorise this, cognitive change strategies use working memory and long term memory to support learning, decreases, increases or maintain activity in the emotional appraisal systems of the brain (Ochsner & Gross, 2005) such as the amygdala. This links to soundscape work such as Irwin et al., (2011). Moreover, Snyder et al., (2012) discuss how mental processes change auditory perception stating that high level processes such as previous knowledge greatly impact auditory perception. Therefore, although the findings are not complete, the triangulation of views from cognitive research and soundscapes shows that SSI can be used as a means to regulate the perceptual response to a hospital soundscape by providing knowledge and understanding.

This approach offers potential to children as their perceptions of disturbing or distressing sound is related to their ability to cope or control the sound (Dellve et al., 2013). Information might be of use, particularly as environment that provides children and young people with the perception of environmental congruence assists in creating improved well-being (Bishop 2008). The theory needs further consideration in the context of soundscape perception as Ochsner & Gross (2005) state cognitive control strategies are context dependent. Indeed, Baker & Berenbaum (2007) remark that emotion focused coping, which SSI arguably aims to facilitate, can directly influence one’s mood by increasing insight and causal thinking. They cite Folkman & Moskowitz (2000) to state such insight can help one believe that the stressor is not something to be feared and can even enable an individual to find positive meaning in the on-going stressful event which is most important in sensory deprived (Wilson, 1972) hospital facilities.

7.2.6. The emotional cognitive perceptual space

The perceptual space measuring the emotional-cognitive response also holds a certain application beyond the CT ward environment (Figure 34).

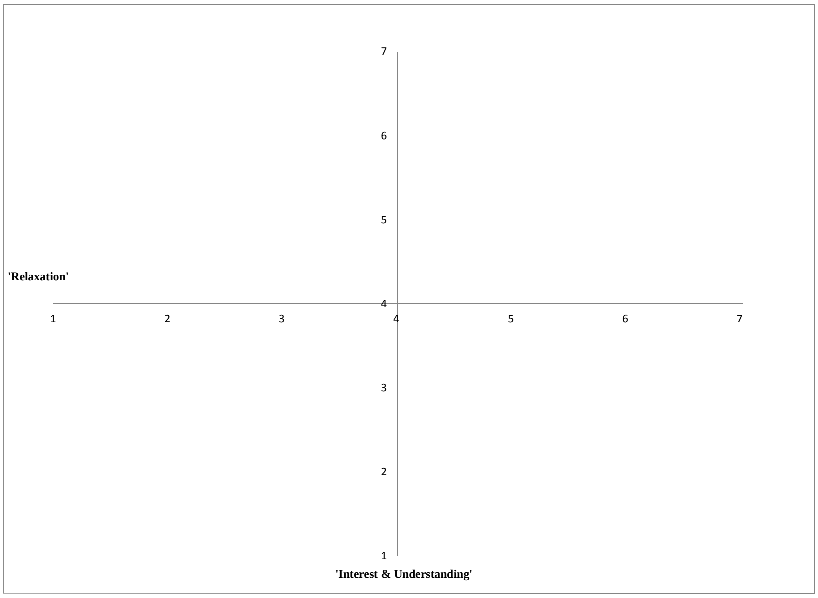

Figure 34. The perceptual space of hospital ward soundscape perception.

Defining this came from variety of data sources (interviews and listening evaluations). This increases the reliability and validity particularly when considering their use in the studies presented above. Importantly, when compared to literature that discusses healing hospital design (Altimier, 2004; Dijkstra et al., 2006), the crucial aim for such environments is one that facilitates comfort. Inherently, this implies relaxation, which supports the principal extracted dimension. The ‘Relaxation’ element of the soundscape accounted for 56.4% of the feeling the soundscape elicited in the listening evaluation. Concurring with literature (Ulrich, 1992; Topf, 2000; Rice, 2003) and interview data, this framework depicts the hospital soundscapes as potentially stressful/uncomfortable for individuals. As such a ward soundscape should aim to facilitate ‘Relaxation’ to counteract this and improve the emotional-cognitive response. As with the conceptual model, the dimensions of the space could be used to assess different hospital soundscapes and map the effectiveness of any alterations to improve the sound quality of the environment.

The perceptual space is comparable to those produced in urban soundscape work. In a general sense the similarity in the perception elicited by a soundscape (urban vs. healthcare) appears to have some uniform characteristics considering the results of other studies - particularly the interest element of perception. Both Guillen & Lopez Barrio (2007) and Hall et al., (2011) found a second dimension of urban soundscape perception to related to ‘informed-not informed’ and ‘confusion’ respectively. These increase the usefulness of the perceptual space to a variety of hospital spaces as, to a certain degree, these attributes are similar to the urban environment and therefore perception of a soundscape, in different contexts, is broadly similar.

The scales defining the secondary dimension ‘Interest & Understanding’ are comparable with the above cited work when considering their semantic meaning. This dimension requires further development to ensure they are interpreted and understood accurately, particularly as it accounts for a smaller element of perception. Nevertheless, it provides a foundation with which to map perception to a hospital soundscape which, used in conjunction with the conceptual model, may highlight areas of improvement to the soundscape.

7.2.7. Sound sources and Sound pressure level

Although not the sole aim, the project was able to investigate the relationship between SPL and perception. Existing research (Akansel and Kaymakci, 2008, Bailey and Timmons, 2005, Busch-Vishniac et al., 2005, Cabrera and Lee, 2000) cite the excessive levels in comparison to the WHO guidelines. It was found that the CT ward was no different, with SPLs comparable to other research - 64.17dB(A)$^{95\%}$ and 62.28dB(A)$^{95\%}$ for the corridor and bay locations respectively, thus building on the growing evidence that the soundscape within these environments is made of the similar components in terms of sources and the acoustic properties. The perceptual space allowed comparisons between sound clips of different SPL and the response to them. Indeed, there was no significant correlation between the emotional-cognitive response and the SPL. Investigation of this produced some interesting results. For example, when assessing soundscape interventions it is noteworthy that clip 12, containing the sound of nurses talking loudly and laughing with a floor cleaner sounding, was rated more positively across all conditions compared to clip 4, a quiet corridor with monitor beeps, despite the higher sound level - 68.75(A)$^{95\%}$ vs. 64.67dB(A)$^{95\%}$ respectively. In this instance of clip 12, the talking was understood and may have masked other sounds. Therefore, dominant sounds, for example, patients crying, need to be understood to avoid these being negative, which is what may have occurred here.

Generally, occupational sounds were most negative, in terms of their effect on ‘Relaxation’ and individuals’ responses to them, with the most positively rated clips containing background ward sounds with no dominant features, as shown in Chapter 6. These results are supported by the influence of the quiet time period. By controlling the occupational sounds the perception of the environment was “*calmer*”. As stated, the significantly lower SPL and loudness of the corridor locations during quiet time was found (p=.035) with the reduced frequency of trolley movements and general occupational sounds contributing to this. Potentially, these sounds are mostly responsibly for causing high sound level. Limiting these sounds is a way to control this within any healthcare spaces and may facilitate the sense of ‘Relaxation’ for patient. However, one nurse said with regard to quiet time:

N: It’s nice but not all the time…it’s unrealistic.

This suggests this period impacted on the work practices of the nurses which is unsustainable thus, providing further support for other intervention which improve patient perception, such as natural sounds and SSI.

7.3. Learning from the research process

The continual iterative analysis throughout the project enabled constant theorising of each finding in relation to the aims and objectives of the project. Throughout the project, psychology theory was increasingly used, supporting the psychological aspect to soundscape perception which much research has acknowledged (Truax, 1984; Moore, 2003; Irwin et al., 2011; Hall et al., 2011). The methodology used the CT ward as a case study, yet because of the domain of healthcare environments the findings, as discussed, can be applied to other wards. This demonstrates how the theories from psychology can be applied to design and engineering solutions in considering sound within an environment. Indeed, the research has shown that to consider sound within a hospital environment, a holistic iterative approach has to be taken to examine positive and negative aspects to form rational solutions to problems and not just consider sound level as the single influencing factor.

The project put the existing and potential users of the CT environment at its fore, constantly ensuring that it was their emotional-cognitive response that was ‘designed’ for. This considered the interaction of people and environments with a theoretical understanding (Wilson, 2000). As sound is intangible, it is possible it can be overlooked in the design of hospital spaces, certainly in the sense of ‘designing’ it for the user. Automotive sound quality research (Kim, Lee & Lee, 2009; Jennings et al, 2010) does this but there is no reason this should not be expanded. This project has begun to suggest how this view could be changed.

Figure 35 shows some aspects that are or should be considered from a general ergonomics perspective. The soundscape approach fits into this as it utilises many of the components of the model such as social, cognitive, emotional and physical, to design the soundscape for the maximum benefit. The findings do not assist designing more specific sounds, such as alarms or monitors, but it does considers the need for these to promote understanding to facilitate ‘Relaxation’ which, future design of these sound sources could consider. Indeed, as Gustavino (2006) suggests it is necessary to understand the cognitive representation of the components of a soundscape before modifications can be made. For this reason, the methodology and models of the project are inherently tied to the discipline of ergonomics as it places the user at the core of the research process.

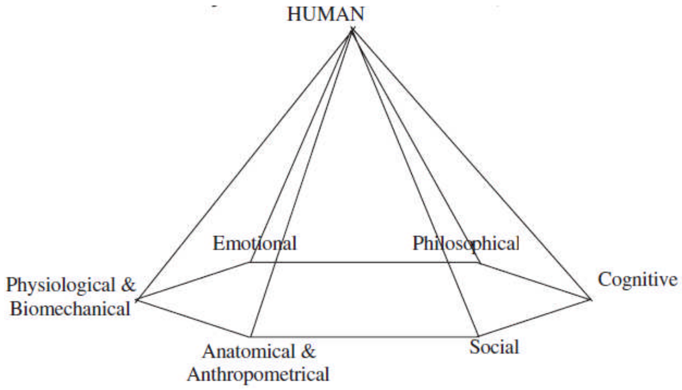

Figure 35. A variation of the ergonomics model presented in Hignett & Wilson., (2004) showing the components necessary to design for human use.

7.3.1. Evaluation of research methodology

The findings of the project produced a comprehensive assessment of the CT soundscape as the study of soundscapes involves diverse fields of practice, approaches and interdisciplinary interests (Brown et al., 2011). SPL has been explored extensively but this never appeared to move on the knowledge regarding the sound of hospital environments. This holistic approach allowed the triangulation of various data sources results to build a picture of how sound in such environments can be improved. The key to this approach is using qualitative methods to explore the perception of sound allowing a comprehensive understanding to be made and visualised through the construction of the conceptual model of soundscape perception. This phenomenological approach meant that a solid basis for further work is established by highlighting where positive sound could be explored and underpinned by a thorough rationale. Perhaps most importantly, the various methods used showed that the results of qualitative research are not mutually exclusive in facilitating the design and interpretation of quantitative testing. Therefore using both methods with a qualitative dominant cross over (Williams and Vogt, 2011) to explore subjective attributes, may be the most robust way to do so. This avoids preconceptions or ideas existing regarding the phenomenon under investigation such as the soundscape.

This approach developed the view that SSI can influence soundscape perception, something that had not been previously considered in the area. This only developed from the qualitative element of the research, which highlighted the benefit of triangulation and is a practical demonstration of how mixed methods research can be used to build and test a new theory in a robust way. Therefore, the application of the methods and tools developed here provide a comprehensive assessment of a hospital ward soundscape.

7.3.2. Limitations of work

As with any work, limitations are present. The specific limitations associated with each study are mentioned in their corresponding chapters, here, the most prevalent limitations are described. Firstly, the use of statistical methods needs justifying. The validity of the statistics used to report, quantify and justify the results relies on the assumption that personal judgements about the response to a soundscape can be reduced to a set of dimensions (Hall et al., 2011). Indeed, Hall et al., (2011) remark when concluding their paper, questions are raised as to how individuals govern their judgements about soundscape perception and how can these be measured when individual response varies so greatly. To justify these concerns an explanation can be given based on the question posed to extract the emotional-cognitive response and test the soundscape interventions. This was based on *"Listen to the soundscape. How does it make you feel?"* A feeling is a concept that many people understand. By providing semantic scales, irrespective of the number of these, a set of parameters for this ‘feeling’ is defined and given. In the analysis it assumes that each individual’s definition of that ‘feeling’ is the same, which, to a certain degree is controlled by providing bipolar anchors to provide tighter parameters for this expression. This is not full proof and must be acknowledged when interpreting the findings. For instance, this discrepancy may be apparent from the variation in results seen between study B2 and C1. However, using bipolar anchor does go some way for controlling this individual variation.

Using healthcare spaces for such work does present pragmatic problems. Recruitment of participants is something that has to be handled with care and thought. This increased the time it takes to complete studies and often led to an increase in missing data and reduced sample size. As a result, members of the public were recruited for the listening evaluations, with the majority of these from the university community and individuals from other areas. Being a patient in hospital is a stressful experience and coupled with medication and pain. These are factors that may influence the subjective appraisal of the ward soundscape. As the listening evaluation participants were healthy this mediating factor cannot be accounted for in the results. As a consequence, the findings might not be truly representative. However, from a philosophical view, everyone has the chance to become a patient so individuals’ views on the soundscape are important as the Department of Health (2009) support. Furthermore, the interview study aided the contextualisation and interpretation of the experimental results which meant the findings are appropriately considered and interpreted.

More specific limitations are recognised. The semantic scales which represent the ‘Interest & Understanding’ dimension of the emotional-cognitive response require further development and testing. Both scales need to represent the concept of the dimension more closely. This dimension relates to understanding towards the soundscape in an effort to measure the concept of acceptance/habituation. For this reason it can be proposed that the scales ‘interest – uninterested’ and ‘recognised-unknown’ may be more representative than the existing and used ‘curious-uninterested’ and ‘intrigued-bored’ scales. As a result of this ambiguity, the full effect of the dimension may not have been represented. Participants may have felt somewhat unsure regarding the definition of the scale which was reflected in the subsequent rating. Such ambiguity means that the effect of SSI lacks clear interpretation.

The Sound Room listening evaluation environment had limitations in two ways:

1. Mismatch between play back SPL and recorded SPL for each sound clip.
2. Lack of contextual and visual congruence.

The mismatch between SPL recorded and playback may have influenced the subjective rating of the clips particularly as dB(A) is not a linear scale so the variation in SPL is greater. However, despite this the results still are valid and reliable as the focus of the project was to capture the subjective response to the perception of the sounds and the content within them. Importantly, the listening test still contained a mix of SPL’s representative of that found within the CT ward. More emphasis was put on the sound clips containing a broad mix of dominant features. Encouragingly, there was little correlation seen between rating and SPL, suggesting the emotional-cognitive response was independent of this factor.

It was decided that visual stimuli was not presented to participants. This was to increase the control within the experiments and ensure that only the sound was being rated. However, from the results of the final in-situ questionnaire study it was apparent that visual identification of sound sources and information of the visual environment influenced the ratings and effect of SSI. For this reason visual stimuli matched to the sound clips in the listening evaluations may have been advantageous. Accepting this, the results provide a base to work from and look at this relationship more closely. This may also provide clearer contextualisation for participants which could be used to validate the perceptual space and to ensure the contribution, in terms of variation accounted by each dimensions, is accurate. This may have influenced the effect of each soundscape intervention.

To test the repeatability of the evaluation procedure, the results of the control condition (existing CT soundscape) in study C1 were cross validated against scores obtained from study B2. The representing scale scores were averaged for each dimension for the same clips (Figure 36).

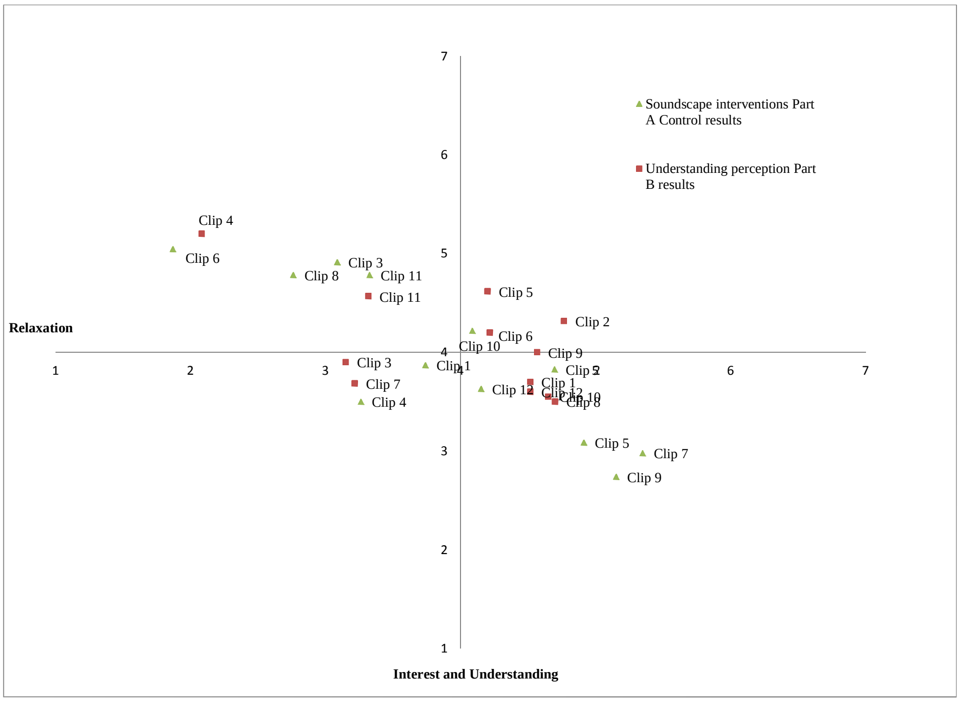

Figure 36. Comparison of clip ratings from PCA study and Soundscape intervention Part A control condition.

An independent t-test was used to assess the difference in response between the same sound clip ratings of the two studies. All data was normally distributed (examination of calculated z-scores). Clip 4 was outside the parameter of normality z=<1.96, but the skewness statistic was <1.0 so was included in the independent t-test analysis. On the ‘Interest & Understanding’ dimension clips 3,4,5,6,7,8,9 produced a significant difference p=<.05 in how they were rated between studies. On the ‘Relaxation dimension clips 1,4,6,7,8 were significantly different in how they were rated (table 24).

Clip	***df***	***t***	***p - value***	**Effect size** $(r = \sqrt{\frac{t2}{t2+df}})$
Interest & Understanding Clip 3	51	-2.819	.007	7.68
Interest & Understanding Clip 4	51	5.154	.001	8.81
Interest & Understanding Clip 5	51	5.057	.001	8.75
Interest & Understanding Clip 6	51	-2.474	.017	7.56
Interest & Understanding Clip 7	51	2.242	.029	7.49
Interest & Understanding Clip 8	51	-4.577	.001	8.48
Interest & Understanding Clip 9	51	4.347	.001	8.36
Relaxation Clip 1	51	2.113	.040	7.45
Relaxation Clip 4	51	-3.771	.000	8.08
Relaxation Clip 6	51	8.286	.000	10.94
Relaxation Clip 7	51	-5.930	.000	9.28
Relaxation Clip 8	51	6.604	.000	9.73

Table 24. Independent t-test results for significant differences in clip rating in comparison to study C1 and B2.

Therefore, the repeatability of the experimental procedure may be limited. However, in study B more scales were rated which may have altered the rating of the ‘Relaxation’ and ‘Interest & Understanding’ scales due to the comparison against other sematic pairs with differing bipolar anchors. This would cause a change in interpretation of them as these ‘feelings’ would be subconsciously compared when rating the sound clips. However, from Fig 5, the general trend is the same with a slight inverse relationship.

7.4. Future work

The project highlighted a number of opportunities for future work. As discussed in the limitation section, the semantic scales measuring the emotional-cognitive response require further development particularly on the ‘Interest & Understanding’ dimension. The relationships between the two dimensions could be further examined. For instance, based on the findings, the question is does understanding facilitate relaxation? Correlation and regression analysis could be used to assess if this relationship exists using the key interventions of natural sounds and SSI. Once done, there are other areas to be investigated by soundscape practitioners:

1. Testing natural sounds in-situ during both quiet and non-quiet time to assess if there is a positive effect.
2. Test the effect of SSI on a younger sample based on the theoretical interpretation of the results. Particularly a paediatric ward.
3. Testing the application of the conceptual model of hospital ward soundscape perception in other healthcare environments.

Natural sounds could be tested in situ to see if the same effect occurs in the ward environment. From the positive association to nature the interviewees had, this seems a logical study to carry out. This could be run during quiet time, in an effort to enhance the time, as well as in periods of normal activity. This would assess the optimum time to create a positive soundscape using this intervention.

Based on the theoretical interpretation of the findings study C2 in relation to the work of Folkman & Lazarus (1988), the effect of SSI on the soundscape perception could be tested on a ward with a lower mean age. Folkman & Lazarus' (1988) results were based on a 'young group', 39.6 and 41.4 years for female and male participants respectively. Considering a more acute application of this, SSI may benefit a paediatric ward in helping children become accustomed to the ward environment. This makes for a logical argument. Using the notion that, perception to the auditory environment is grounded in the within individuals' experience and knowledge (Dubios et al., 2006), children have less tacit knowledge, due to their age, about their environmental surroundings which SSI could change. This might be useful in creating a familiar, relaxing, understood hospital environment for children, which is important as children’s feeling of well-being is linked to their ability to feel comfortable in the environment (Bishop, 2008). Therefore, SSI may achieve a positive reappraisal. This has potentially exposed a new research area, which looks at how the reappraisal (the generation of a new emotion) of an environment’s soundscape can be facilitated using information. The two of different types of information, situational and emotional, put forward by Baum et al., (1981) would need to be tested to find the most effective based on the environmental context, soundscape components and user demographic. This is important as it Baker & Berenbaum (2007) explored for whom and under what circumstances emotional-focused coping is effective and found that individuals who are clear about their emotions had little to gain by engaging in emotional-approach coping. Such individuals have the requisite information to effectively solve their problems and are apt to be insightful regarding their problem (Baker & Berenbaum, 2007). Therefore, children may be helped by information in assisting them to understand their feelings when exposed to a hospital soundscape.

Finally, the conceptual model underpinned the experimental research from the start. This could be validated by creating a survey assessing the components of the model to be distributed throughout a hospital, testing the generalisation of it across facilities. This would then help create strategies for providing a more positive soundscape and measure the contribution each component of the model has to the overall emotional-cognitive response. Application could also be of practical help in managing sound in these spaces beyond the SPL guidelines by developing the model as the basis of an audit tool for hospital environments.

7.5. Personal reflections on the research

The project was a success in many ways as it managed to develop and test very different soundscape intervention. On a personal level the researcher was pleased that patients bookmarked the research process. Ultimately, the aim of the work was to improve the perception of the CT ward for this group. Researching within healthcare spaces revealed pragmatic issues and trade-offs which have to be considered in deciding whether in-situ or laboratory testing should be used. There are many ethical considerations not just with participation but also bringing equipment into the ward environment, for example, infection control. Therefore, setting up listening evaluation on a patient demographic using a binaural headset is challenging which is why this was not used.

Gaining an adequate sample size using patients as participants is also problematic. From the experience of conducting the project when involving patients a 50% drop out rate has to be expected. For this reason when powering a study to achieve robustness, this doubles the sample size needed. As a result the time it takes to complete any study is extrapolated. Due to the time constraints associated with PhD research this was not possible, and the trade-off was removal of this sample demographic in replacement for increase experimental control using a laboratory setting and convenience sampling. Despite this, the project successfully balanced the two constraints by involving a variety of groups to answer the research aims and objectives in the most robust, feasible way.

Associated with participation, there is a need for participants to have an active interest in the topic under investigation. Fortunately, the CT ward was a supportive and encouraging environment. Only a few comments were received questioning the importance of considering sound in the environment. On the whole patients were more aware of their surroundings than nurses. This is not surprising as they are not involved in work activities resulting in reduced distractions as cited in various literature (Ulrich, 1992; Rice, 2003). Certainly, one comment by a nurse stands out highlighting this:

> ***And do you notice sound with the activities that are going on?***
>
> *N: Not until the other day when I noticed you doing that! [Recording sounds] Because you are in the environment, you know, you're doing your job, you're not taking that moment to stop and listen. But I sort of did the other day when you did that. We were told to be quiet and it was quiet time, but the sounds you can hear...we just forget them.* **You just get used to them?**
>
> *N: Yes you don't really stop and think, but that sort of made me realise how much noise there is.*

This brings us to discuss the involvement of medical staff. All the staff in the CT ward were generous with their time which they applied to the research. However, much like patients, the challenge is to create data capture methods that are quick and accurate to avoid inconvenience to this group. Doing this successfully would increase the amount of data obtained. Certainly, this is an area future work could pick up on.

Therefore, future work could and should be carried on by soundscape practitioners, hospital planners and designers or medical, psychology or engineering researchers. The potential to look at the perception of the soundscape in a clinical trial offers an exciting way to link the development of a robust positive soundscape intervention such as SSI to patient outcomes. Furthermore, this highlights the multidisciplinary aspect to this work.

CHAPTER 8

CONCLUSIONS

8.0. Conclusions

This section provides a synthesis of the findings by remarking on the key outputs from the research. The question posed at the beginning of the project was *‘what is the perception of a hospital ward soundscape and how can this be improved?’*

Objective 1. To capture, analyse and represent the perception and feelings of patients and staff towards a hospital ward soundscape.

The conceptual model of hospital ward soundscape perception developed from patients’ and nurses’ interviews which mapped their sensitivity towards the hospital ward soundscape. The model showed the links and relationships between the concepts that depict peoples’ perception of the CT ward soundscape. Most importantly, it highlights the key aspect of acceptance and habituation to sounds, which form a coping method by which individuals deal with the hospital soundscape. These form the bridge between the physical attributes of the soundscape; sound source, sound level, and time, to the subjective response. This appraisal processes forms the perceptual response to the soundscape. Importantly, these could be manipulated by interventions which alter the emotional-cognitive response of the individual.

Furthermore, occupational sounds such as trolleys and cleaning equipment among others, were perceived negatively in the ward, creating a more stressed feeling in patients and nurses. Control of these sound sources through daily ‘quiet time’ could produce a more positive response in facilitating a calming and *“recharging”* feeling for individuals in the ward. This can be attributed to the control of these occupational sounds. Therefore, a ‘quiet time’ is an easy way to improve the emotional-cognitive response to the soundscape for both patients and staff.

Objective 2. To record and analyse the objective attributes of the same hospital ward soundscape for reference, contrast and comparison with current literature.

The analysis of the SPL (dB(A)) of the CT ward showed comparable levels to those cited in the literature, for example, Akansel & Kaymakci (2008). Interestingly, it appeared that occupational sounds contributed to high SPL and loudness. Indeed, during quiet time, sound levels were significantly lower which can be attributed to the control of occupational sounds.

Importantly, the listening evaluation results showed no correlation between the emotional-cognitive response and SPL. As such, objective data is limited in use when aiming to improve the perception of sound in hospital environments. Therefore, this provides evidence that it is the content of the sound that is important, along with the meaning and interpretation of it for the individual. For example, necessary sounds are accepted and therefore do not create a negative response even if they may be loud. This also showed that the CT ward is comparable to many other healthcare spaces thus providing validity to the findings and conclusions.

Objective 3. To create a perceptual space to represent and measure the subjective response to the hospital ward soundscape.

Perception of a hospital ward soundscape can be measured in the perceptual space by the emotional-cognitive response of ‘Relaxation’ and ‘Interest & Understanding’. These orthogonal dimensions hold some parallels to urban soundscape work suggesting that perception to a soundscape in essence is similar across different environments. Indeed, ‘Relaxation’ accounts for 56.8% of the perceptual response of the hospital soundscape similar to the ‘Pleasantness’ and ‘Calmness’ dimension seen in urban work

(Axelsson et al., 2010; Cain et al., 2011; Hall et al., 2011). The secondary dimension concurs with ‘Information content’ from Guillen & Lopez Barrio (2007). These dimensions were represented by four bipolar semantic scales captured from both the interview and listening evaluations which can be used to assess the ward soundscape. Therefore, it can be concluded that the perception of a hospital ward soundscape is represented by an emotional feeling relating to ‘Relaxation’ and also a cognitive aspect of ‘Information & Understanding’. Furthermore, hospital soundscapes can be classified and positioned within this simple two-dimensional space.

Objective 4. To identify, test and measure interventions that potentially give a more positive response to the hospital ward soundscape.

Using this perceptual space, the investigation of interventions to the soundscape led to two conclusions. Firstly, natural sound was consistently the most positive intervention and facilitated perceived ‘Relaxation’. This intervention could now be formally investigated in-situ within a ward environment to understand its effectiveness in producing a more positive emotional-cognitive response in patients. However, this does pose problems with the feasibility of such an intervention.

On the other hand, sound source information was tested in-situ. The use of information to influence soundscape perception was something that had not been considered by previous work and offers a new avenue for research. It was found that this form of information significantly affects hospital soundscape perception when measured using the presented emotional-cognitive perceptual dimensions. Notably, the final in-situ study found that in the CT ward context, and with a patient demographic, the effect did not influence ‘Relaxation’ but did contribute to reduced curiosity by affecting

‘Interest & Understanding’. This supported the rationale behind the intervention which potentially facilitated coping. This intervention, although needing more conclusive work, could be used as a coping strategy to help patients understand and deal with the novel and new sounds of a hospital environment. Importantly, this may generate a reappraisal and thus a new more positive emotional-cognitive response. Excitingly, depending on the demographic characteristics, information on the soundscape may provide a means to positively influence the soundscapes effect of ‘Relaxation’ in a hospital ward environment.

8.1. Final Remarks

The reference of Florence Nightingale (1863) is often used to justify research of this type:

> “*People say the effect is on the mind. It is no such thing. The effect is on the body, too. Variety of form and brilliancy of colour in the objects presented to patients is the actual means of recovery*”.

The soundscape influences both patients and nurses subjectively. Producing a positive emotional-cognitive response improved a person’s perception to the CT ward soundscape. This is something that physical acoustic measures miss. The result of considering the effect on the ‘*mind*’ has highlighted sound source information as a potentially simple, yet novel way to influence perception and responses to a hospital ward soundscape. This can now be investigated further as a viable way to influence the perception of sound in these spaces. Then the *‘effect on the body’* may then be investigated fully to answer if a positive soundscape can be achieved.

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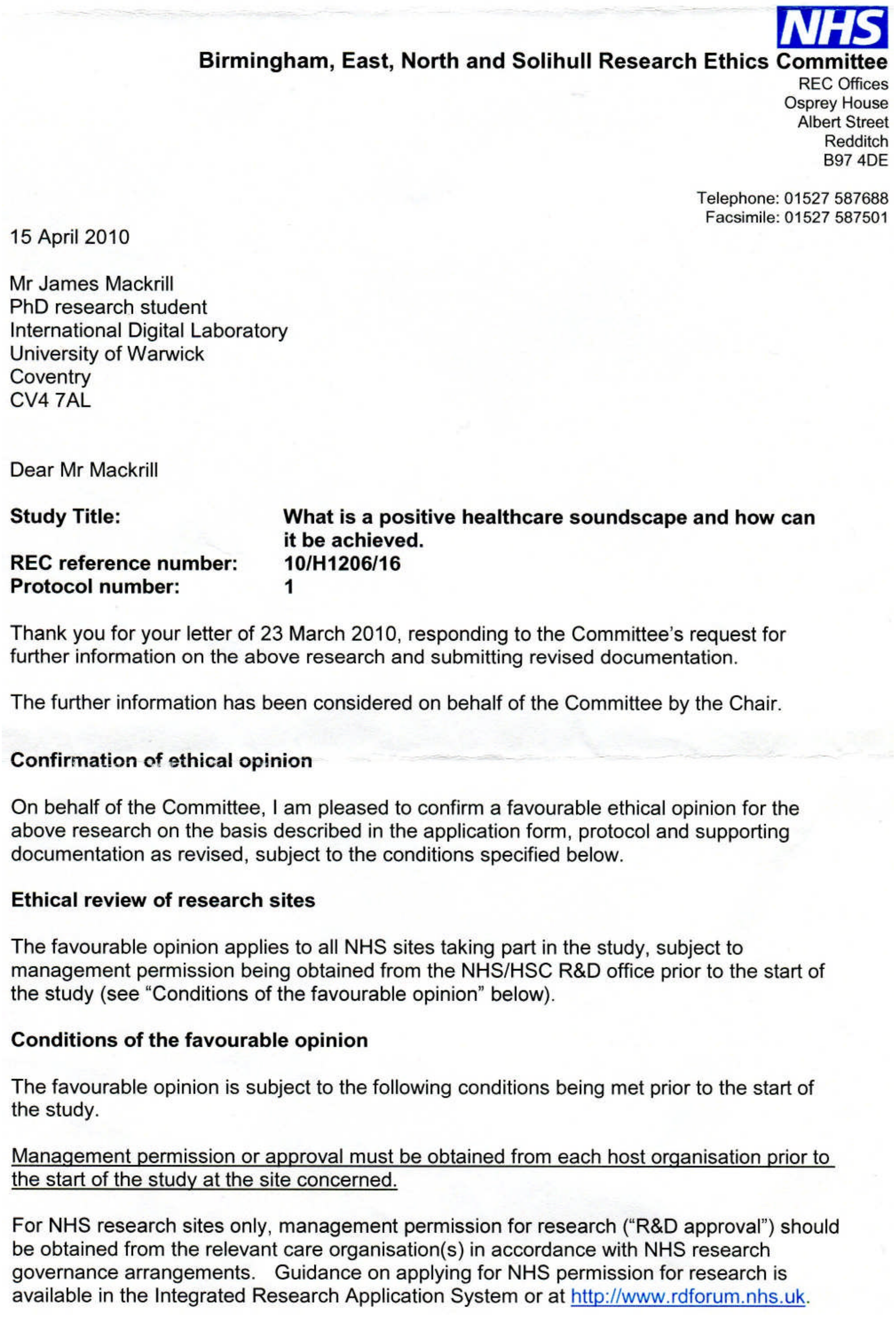
APPENDICIES

APPENDIX 1: NHS Research ethics approval letter



Birmingham, East, North and Solihull Research Ethics Committee
REC Offices
Osprey House
Albert Street
Redditch
B97 4DE

Telephone: 01527 587688
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15 April 2010

Mr James Mackrill
PhD research student
International Digital Laboratory
University of Warwick
Coventry
CV4 7AL

Dear Mr Mackrill

Study Title:	**What is a positive healthcare soundscape and how can it be achieved.**
REC reference number:	**10/H1206/16**
Protocol number:	**1**

Thank you for your letter of 23 March 2010, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

For NHS research sites only, management permission for research ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

APPENDIX 2: Understanding Perception: Interview study

2.1. Nurse interview schedule.

Introductory script for interview

"The aim of this interview is to gain your perception and feelings towards the environment in which you work. When talking about the environment this includes the built environment, but also sounds, sights, smells, temperature, colour, light, windows – everything that you notice in the environment where you work."

"I am interested in how the environment and sounds that people hear in hospital make them feel and how sound can be used to have a positive impact on the people within the healthcare environment."

"I am going to ask a few questions regarding this environment where you work which you can respond how you wish. There is no right or wrong answer and all information is anonymous. The interview will be recorded and once the interview has been completed I will transcribe the results to look at how people describe the environment and how it makes them feel".

Interviewee data:	
Age:	
Duration worked in healthcare environment:	
Job title:	
Name, address and area of the healthcare environment you work in:	

Contact Information (only used to provide written transcript for approval if participants wish)	
Name	
Address	
Email (transcripts can be emailed to you if preferred).	

Interview data	
Date:	
Time:	
Name and location conducted in:	
Duration of interview:	

Interview schedule

Establishing context

- What is your job and can you briefly describe what you do?
    - Do your duties change with the time of day?

Undirected broad questions on the environment:
"If we start off by talking about the environment where you work and think about it in relation to how you work..."

- Can you describe this environment you work in and the activities that occur here?

- What aspects of the environment do you notice?
    - Can you describe why?
    - Do you like/dislike these things?
- Do you notice anything(s) which dominates the environment?
    - (This might be sounds, light, temperature, colour that you particularly notice?)
    - Is this good or bad?
- How does the environment make you feel?
    - Can you say why or what causes this?
    - What makes you feel positive or negative?
    - What makes you feel negative?
- Do you notice anything that makes the environment seem better for you? For example the time of day, activities that may be happening etc.
    - Why is this?
    - What makes the environment seem worse for you?
- Which areas of the environment do you like being in the most or least?
    - Why is this?
- Does environment help you do your job?
    - Does the environment hinder your job in anyway? (Explain if answer given)

Directed questions regarding sound:
"In the following questions I want to get you to think about sound and the environment."

- Do you notice sound much?
    - Are these different sounds or the same sounds?

- Are there certain times when sound is more noticeable?
    - Why?
    - How does this make you feel?

- What are positive sounds that you notice?
    - If 'Yes' how would you describe these?
    - How do they make you feel?

- What are negative sounds that you notice?
    - If 'Yes' how would you describe these?
    - How do they make you feel?

- Are there sounds which are important to you?
    - Why?
- Are there any sounds in particular that affect you?

- What benefits does sound provide to you?

Further views

- What aspect of the healthcare environment would you improved?

        - If suggestions are made why?

Probes – If ‘noise’ or ‘sound’ is mentioned

- Do you notice sounds within the environment?
- How does it make you feel?
- What causes noise do you think?
- Are there any aspects to it (sounds) which you like?
- Do you think the environment would be improved by considering this?

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2.2. Patient interview schedule.

Introductory script for interview

"The aim of this interview is to gain your perception and feelings towards the environment in which you are a patient. When talking about the environment this includes the built environment, but also sounds, sights, smells, temperature, colour, light, windows – everything that you notice in the environment where you work."

"I am interested in how the environment and sounds that people hear in hospital make them feel and how sound can be used to have a positive impact on the people within the healthcare environment."

"I am going to ask a few questions regarding the environment where you mostly work, e.g. the specific ward etc which you can respond how you wish. There is no right or wrong answer and all information is confidential. The interview will be recorded and once the interview has been completed I will transcribe the results to look at how people describe the environment and how it makes them feel".

Interviewee data:	
Age:	
Gender:	
Length of hospital stay:	

Contact Information (only used to provide written transcript for approval if the they wish):	
Name	
Address	
Email (transcripts can be emailed to you if preferred).	

Interview Data:	
Date:	
Time:	
Name and location conducted in:	
Duration of interview:	

Understanding the healthcare soundscape
Patient Interview schedule
Establishing context

- How long have you been in the hospital?
- What's it like being a patient here?

Undirected broad questions on the environment:

"If we start off by talking about the environment where you work and think about it in relation to how you work..."

- Can you describe this environment you are in and the activities that occur here?
    - What activities do you do while you are here?

- What things in the environment do you notice?
    - Can you describe why?
    - Do you like/dislike these things?

- Do you notice anything(s) which dominates the environment?
    - (This might be sounds, light, temperature, colour that you particularly notice?)
    - Is this good or bad?

- How does the environment make you feel?
    - Can you say why or what causes this?
    - What makes you feel positive or negative?
    - What makes you feel negative?

- Do you notice anything that makes the environment seem better for you? For example the time of day, activities that may be happening etc.
    - Why is this?
    - What makes the environment seem worse for you?

- Which areas of the environment do you like being in the most or least?
    - Why is this?

Directed questions regarding sound:

"In the following questions I want to get you to think about sound and the environment."

- Do you notice sound much?
    - Are these different sounds or the same sounds?

- Are there certain times when sound is more noticeable?
    - Why?
    - How does this make you feel?

- What are positive sounds that you notice?
    - If 'Yes' how would you describe these?
    - How do they make you feel?

- What are negative sounds that you notice?
    - If 'Yes' how would you describe these?
    - How do they make you feel?

- Are there sounds which are important to you?
    - Why?
- Are there any sounds in particular that affect you?

- What benefits does sound provide to you?

Further views

- What aspect of the healthcare environment would you improved?
    - If suggestions are made why?

Probes – If 'noise' or 'sound' is mentioned

- Do you notice sounds within the environment?
- How does it make you feel?
- What causes noise do you think?
- Are there any aspects to it (sounds) which you like?
- Do you think the environment would be improved by considering this?

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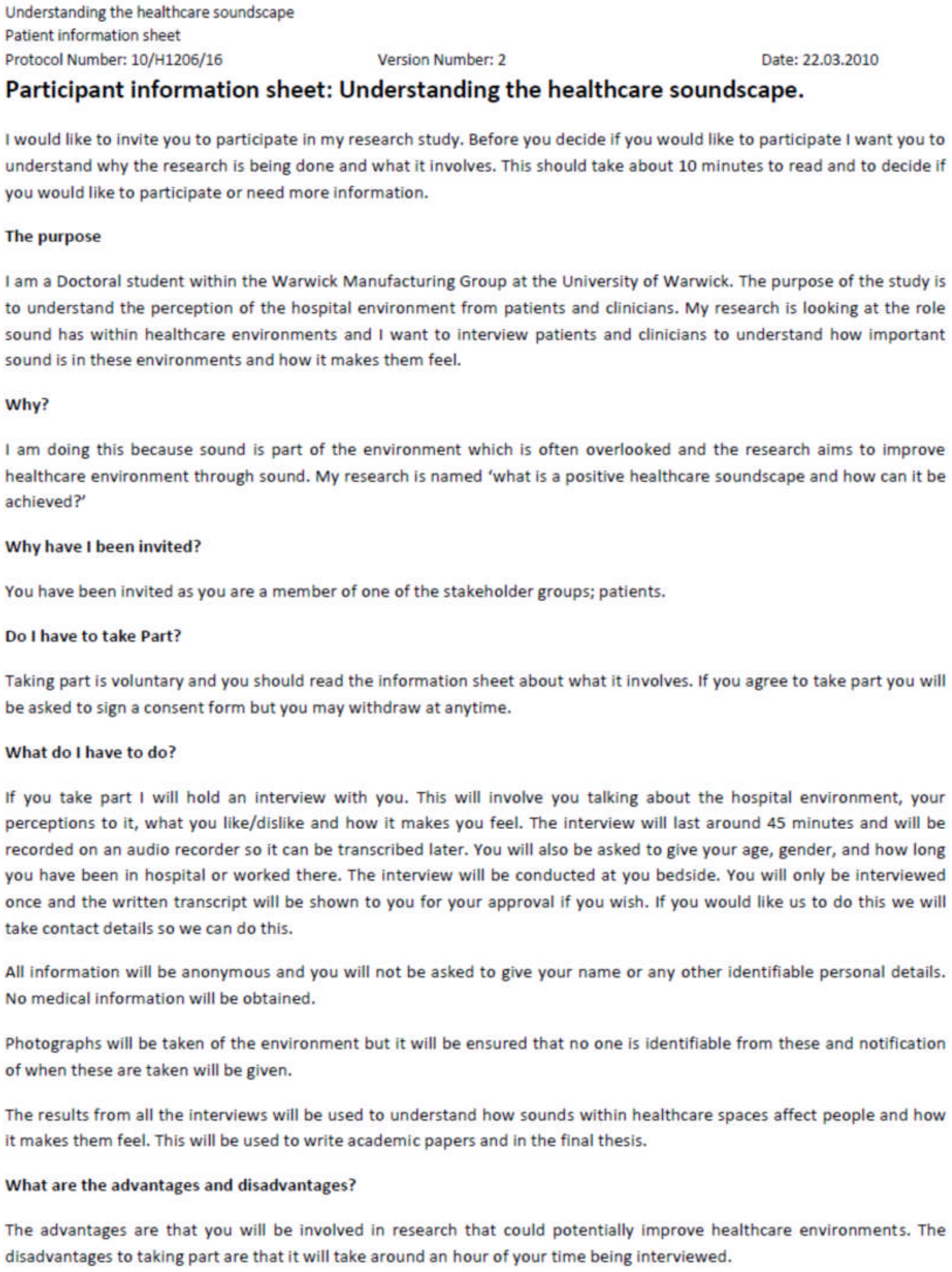
2.3. Participant information sheet and consent form. Note, Patient information sheet followed by nurse information sheet.



Understanding the healthcare soundscape
Patient information sheet
Protocol Number: 10/H1206/16 Version Number: 2 Date: 22.03.2010

Participant information sheet: Understanding the healthcare soundscape.

I would like to invite you to participate in my research study. Before you decide if you would like to participate I want you to understand why the research is being done and what it involves. This should take about 10 minutes to read and to decide if you would like to participate or need more information.

The purpose

I am a Doctoral student within the Warwick Manufacturing Group at the University of Warwick. The purpose of the study is to understand the perception of the hospital environment from patients and clinicians. My research is looking at the role sound has within healthcare environments and I want to interview patients and clinicians to understand how important sound is in these environments and how it makes them feel.

Why?

I am doing this because sound is part of the environment which is often overlooked and the research aims to improve healthcare environment through sound. My research is named 'what is a positive healthcare soundscape and how can it be achieved?'

Why have I been invited?

You have been invited as you are a member of one of the stakeholder groups; patients.

Do I have to take Part?

Taking part is voluntary and you should read the information sheet about what it involves. If you agree to take part you will be asked to sign a consent form but you may withdraw at anytime.

What do I have to do?

If you take part I will hold an interview with you. This will involve you talking about the hospital environment, your perceptions to it, what you like/dislike and how it makes you feel. The interview will last around 45 minutes and will be recorded on an audio recorder so it can be transcribed later. You will also be asked to give your age, gender, and how long you have been in hospital or worked there. The interview will be conducted at you bedside. You will only be interviewed once and the written transcript will be shown to you for your approval if you wish. If you would like us to do this we will take contact details so we can do this.

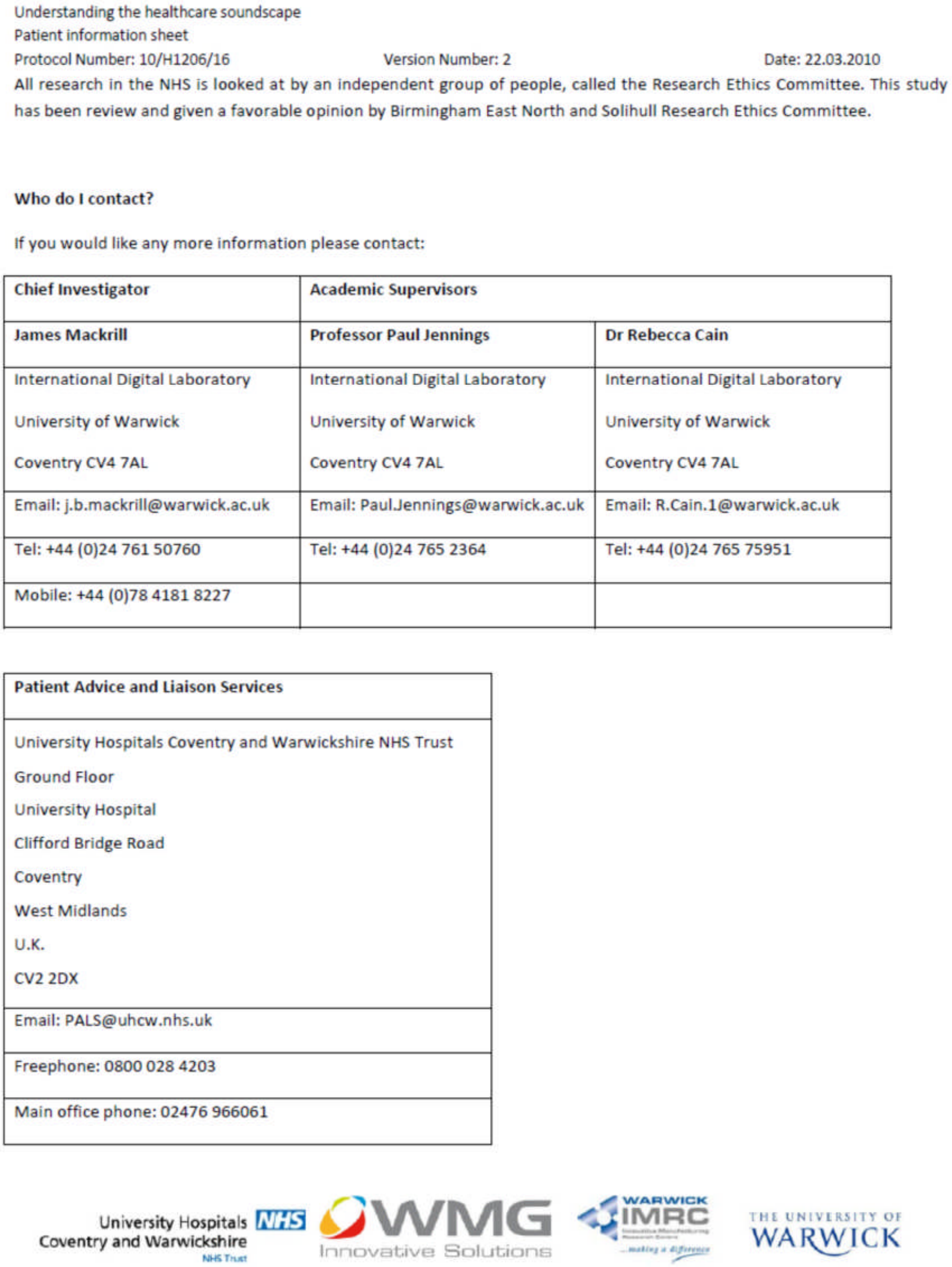
All information will be anonymous and you will not be asked to give your name or any other identifiable personal details. No medical information will be obtained.

Photographs will be taken of the environment but it will be ensured that no one is identifiable from these and notification of when these are taken will be given.

The results from all the interviews will be used to understand how sounds within healthcare spaces affect people and how it makes them feel. This will be used to write academic papers and in the final thesis.

What are the advantages and disadvantages?

The advantages are that you will be involved in research that could potentially improve healthcare environments. The disadvantages to taking part are that it will take around an hour of your time being interviewed.



Understanding the healthcare soundscape
Patient information sheet
Protocol Number: 10/H1206/16 Version Number: 2 Date: 22.03.2010

All research in the NHS is looked at by an independent group of people, called the Research Ethics Committee. This study has been review and given a favorable opinion by Birmingham East North and Solihull Research Ethics Committee.

Who do I contact?

If you would like any more information please contact:

Chief Investigator	**Academic Supervisors**	
James Mackrill	**Professor Paul Jennings**	**Dr Rebecca Cain**
International Digital Laboratory University of Warwick Coventry CV4 7AL	International Digital Laboratory University of Warwick Coventry CV4 7AL	International Digital Laboratory University of Warwick Coventry CV4 7AL
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Tel: +44 (0)24 761 50760	Tel: +44 (0)24 765 2364	Tel: +44 (0)24 765 75951
Mobile: +44 (0)78 4181 8227		

Patient Advice and Liaison Services
University Hospitals Coventry and Warwickshire NHS Trust Ground Floor University Hospital Clifford Bridge Road Coventry West Midlands U.K. CV2 2DX
Email: PALS@uhcw.nhs.uk
Freephone: 0800 028 4203
Main office phone: 02476 966061

Participant information sheet: Understanding the healthcare soundscape.

I would like to invite you to participate in my research study. Before you decide if you would like to participate I want you to understand why the research is being done and what it involves. This should take about 10 minutes to read and to decide if you would like to participate or need more information.

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Why?

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Why have I been invited?

You have been invited as you are a member of one of the stakeholder groups; clinicians.

Do I have to take Part?

Taking part is voluntary and you should read the information sheet about what it involves. If you agree to take part you will be asked to sign a consent form but you may withdraw at anytime.

What do I have to do?

If you take part I will hold an interview with you. This will involve you talking about the hospital environment, your perceptions to it, what you like/dislike and how it makes you feel. The interview will last around 45 minutes and will be recorded on an audio recorder so it can be transcribed later. You will also be asked to give your age, gender, and how long you have been in hospital or worked there. The interview will be conducted using a 'soundwalk' method were we walk around the department during the interview. You will only be interviewed once and the written transcript will be shown to you for your approval if you wish. If you would like us to do this we will take contact details so we can do this.

All information will be anonymous and you will not be asked to give your name or any other identifiable personal details. No medical information will be obtained.

Photographs will be taken of the environment but it will be ensured that no one is identifiable from these and notification of when these are taken will be given.

The results from all the interviews will be used to understand how sounds within healthcare spaces affect people and how it makes them feel. This will be used to write academic papers and in the final thesis.

Understanding the healthcare soundscape
Clinician information sheet
Protocol Number: 10/H1206/16 Version Number: 2 Date: 22.03.2010

What are the advantages and disadvantages?

The advantages are that you will be involved in research that could potentially improve healthcare environments. The disadvantages are that it will take around an hour of your time.

All research in the NHS is looked at by an independent group of people, called the Research Ethics Committee. This study has been review and given a favorable opinion by Birmingham East North and Solihull Research Ethics Committee.

Who do I contact?

If you would like any more information please contact:

Chief Investigator	**Academic Supervisors**	
James Mackrill	**Professor Paul Jennings**	**Dr Rebecca Cain**
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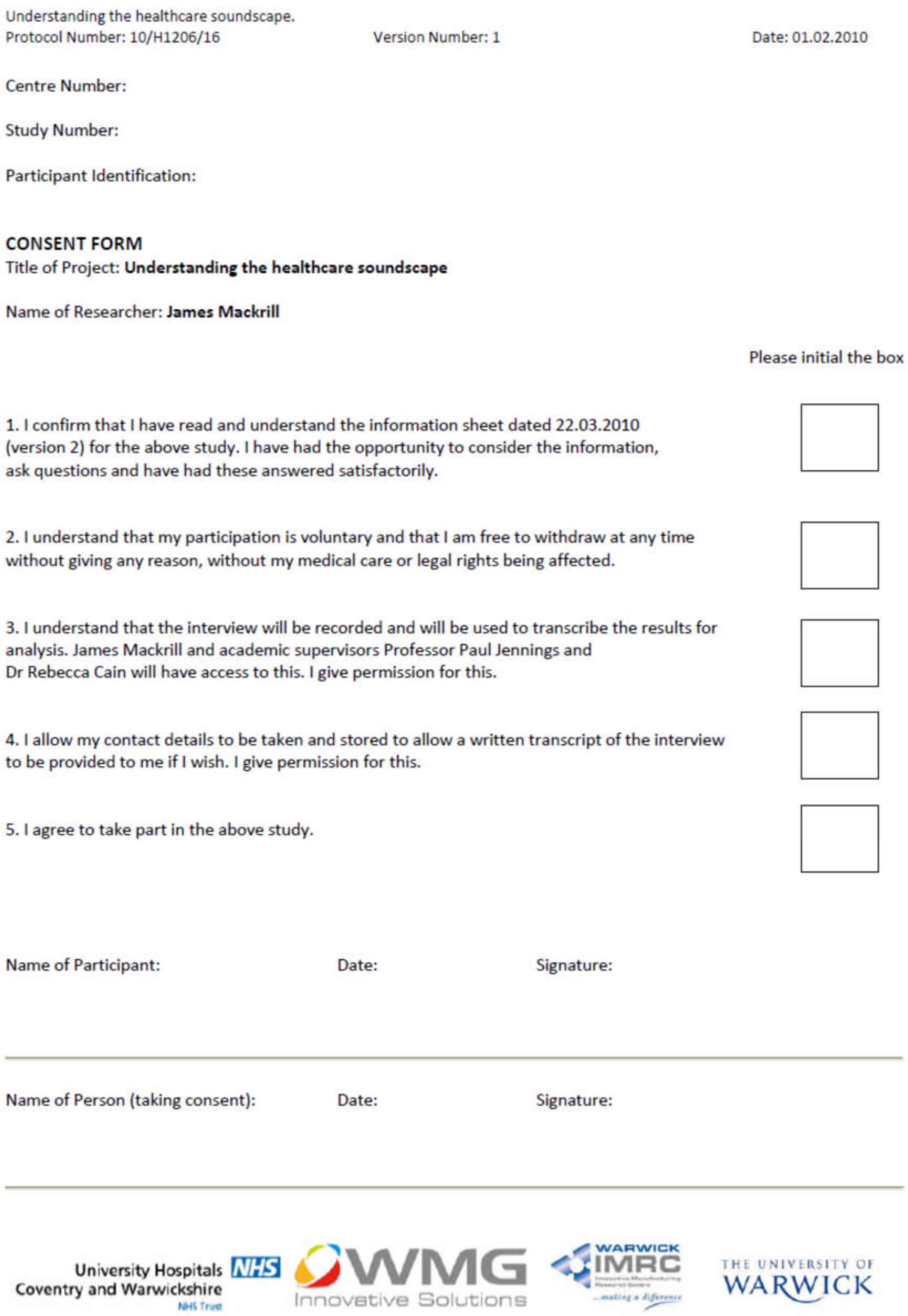
Tel: +44 (0)24 761 50760	Tel: +44 (0)24 765 2364	Tel: +44 (0)24 765 75951
Mobile: +44 (0)78 4181 8227		



Understanding the healthcare soundscape.
Protocol Number: 10/H1206/16 Version Number: 1 Date: 01.02.2010

Centre Number:

Study Number:

Participant Identification:

CONSENT FORM

Title of Project: **Understanding the healthcare soundscape**

Name of Researcher: **James Mackrill**

Please initial the box

1. I confirm that I have read and understand the information sheet dated 22.03.2010 (version 2) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. ☐

3. I understand that the interview will be recorded and will be used to transcribe the results for analysis. James Mackrill and academic supervisors Professor Paul Jennings and Dr Rebecca Cain will have access to this. I give permission for this. ☐

4. I allow my contact details to be taken and stored to allow a written transcript of the interview to be provided to me if I wish. I give permission for this. ☐

5. I agree to take part in the above study. ☐

Name of Participant: Date: Signature:

Name of Person (taking consent): Date: Signature:

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2.4. Table showing interview coding schedule.

Theme	Category name	Category code	Subcategory code	Nurses comments		Patients comments	
				Frequency count	Percentage contribution (%)	Frequency count	Percentage contribution (%)
Perception and influence of sound - Comments regardsing the subjective perception of sound within the environment and the effect upon the individual.	Perception of sound general comment	pos		5	1.15	4	1.0
	Perception of sound positive		pos-pos	11	2.53	15	3.8
	Perception of sound negative		pos-neg	17	3.92	33	8.3
	Perception of sound in background		pos-back	24	5.53	10	2.5
	Perception of sound accept or hibituate		pos-acc/hib	25	5.76	26	6.5
	Perception of sound necessary		pos-necc	10	2.30	3	0.8
	Sound source descrition of sound	ss-desc		7	1.61	11	2.8
	Sound level high	s-lev-hig		31	7.14	17	4.3
	Sound level low	s-lev-low		5	1.15	14	3.5
	Sound problems with privacy	s-pro-pri		3	0.69	6	1.5
	Sound problems with work	s-pro-wk		10	2.30	0	0.0
	Sound problems with sleep	sou-pro-sle		1	0.23	9	2.3
	Sound benefits of information	sou-ben-info		3	0.69	11	2.8
	Sound benefits of stimulation	sou-ben-stim		1	0.23	7	1.8
Sources - Comments regarding sound sources within the environment and perceived sound level.	Sound source people	ss-peo		17	3.92	17	4.3
	Sound source equipment	ss-equi		28	6.45	8	2.0
	Sound source occupational	ss-occ		30	6.91	16	4.0
	Sound source outside	ss-out		2	0.46	5	1.3
	Sound source entertainment	ss-enter		8	1.84	3	0.8
	Sound source other	ss-oth		0	0.00	2	0.5
Emotional response - Comments/words describing the emotional feelings of the individul as a result of sound or another environmental attribute.	Emotional response positive	poe-er-pos		19	4.38	31	7.8
	Emotional response negative	poe-er-neg		31	7.14	21	5.3
Temporal factors - Comments on how time affects activity which related to perception of environment and sound.	Temporal factors associated with daily routine and specific activity	Temp-dr		25	5.76	14	3.5
	Activity level high	act-l-high		19	4.38	4	1.0
	Sound duration	temp-sou-dur		6	1.38	8	2.0
Restoration - Comments relating to the concept of restoration provided by compoents of the environment.	Visual aspect restoration	vis-rest		2	0.46	9	2.3
	Outside stimulation	pae-out-stim-rest		1	0.23	12	3.0
	Sound Restoration	sou-rest		25	5.76	16	4.0
Other Physical attributes - Comments regarding the wider environment including the effect of these attributes on the subjective feelings	Physical aspect to the environment general comment	pae-gen		0	0.00	2	0.5
	Physical aspect to the environment temperature	pae-temp		8	1.84	2	0.5
	Physical aspect to the environment space	pae-spa		3	0.69	4	1.0
	Physical aspect to the environment light	pae-lig		1	0.23	12	3.0
	Physical aspect to the environment outside	pae-out		0	0.00	5	1.3
	Visual Privacy	pae-vis-pri		0	0.00	2	0.5
	Homeliness	pae-home		0	0.00	3	0.8
Comments about future design - Comments, considerations and suggestions about the design of future healthcare spaces.	Improvements to envrionment by other factors	cfd-other		6	1.38	2	0.5
	Comments regarding sound in future design	cfd-soun		14	3.23	13	3.3
	Future design to the environment affecting emotional response	cfd-er		8	1.84	1	0.3
Behaviour of people - Comments on how the behaviour of people affect the perception of the environment	Behaviour of people	beh-peo		18	4.15	6	1.5
Analogy - Description of the perception of the environment or and environmental attribute which is described using an analogy.	Analogy	ana		2	0.46	8	2.0
Job duties - Comments regarding clinical duties.	Job duties	jd		8	1.84	n/a	
Patient interaction - Description of patient interaction within the ward.	Patient interaction	pat-int		n/a		8	2.0

2.5. Tables showing key semantics and frequency count from nurses and patients.

Key semantics (nurses)			
Positive	**Frequency count**	**Negative**	**Frequency count**
Calm	5	Stressed	5
Calming	3	Horrendous	3
Peaceful	3	Annoying	2
Relaxed	3	Frustration	2
Lovely and quiet	2	Insane	2
Relaxing	2	Manic	2
Banter	1	Stressful	2
Brightens you up	1	Aggravate	1
Bustling	1	Banging	1
Calmer	1	Barmy	1
Happier	1	Chaos	1
Listen to yourself	1	Chronic	1
Nice	1	Clattering	1
Recharging	1	Din	1
Tranquil	1	Disruptive	1
		Fuzzy	1
		Grate	1
		Hectic	1
		Huff	1
		Intimidating	1
		Irritate	1
		Irritating	1
		Mad	1
		Nightmare	1
		Ratty	1
		Rile you	1
		Stressing	1

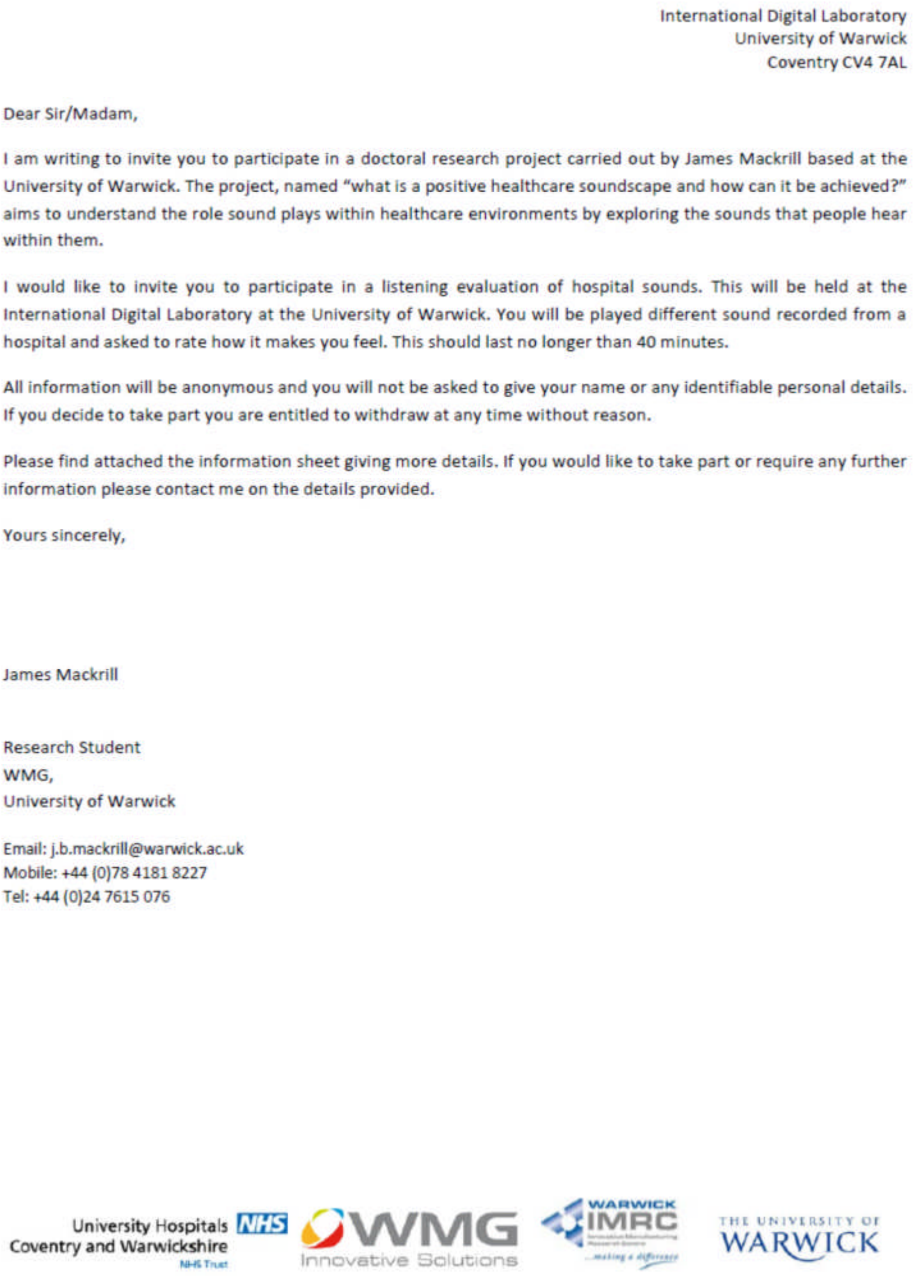
Key semantics (Patients)			
Positive	**Frequency count**	**Negative**	**Frequency count**
Lovely	4	Annoying	3
Comforting	3	Disturbing	2
Relaxed	3	Upsetting	2
Fantastic Sound	2	Annoy	1
Nice atmosphere	2	Annoyed	1
Relaxing	2	Annoys me	1
A treat	1	Awful	1
Beneficial	1	Bloody noise	1
Beautiful	1	Disconcerting	1
Calm	1	Distressing	1
Calming	1	Gets on your nerves	1
Cheers you up	1	Hell of a din	1
Encouraging	1	Irritating	1
Gorgeous	1	nuisance	1
Ideal	1	Noise is tremendous	1
Not unpleasant	1	Put you on edge	1
Peace and Quiet	1	Scary atmosphere	1
Pleased	1	Startled	1
Pleasant	1	Uncomfortable	1
Quiet	1	Unsettling	1
Quite important	1		
Reassuring	1		
Relaxed environment	1		
Secure	1		

2.6. Table showing soundscape coding schedule and frequency counts.

Sound classification			Ward corridor recordings counts (n=19) main corridor	Ward corridor recordings counts (n=19) main corridor percentage contribution (%)	War bay recordings counts (n=6) both step down and main ward areas	War bay recordings counts (n=6) both step down and main ward areas percentage contribution (%)
Source	**Sub Source**	**Action (description)**				
Human	People	coughing	6	5.8	2	6.9
	People	footsteps background	15	14.4	3	10.3
	People	footsteps passing	13	12.5	3	10.3
	People	footsteps squeaking	7	6.7	0	0.0
	People	laughing	7	6.7	4	13.8
	People	passing talking	10	9.6	0	0.0
	People	sneezing	2	1.9	0	0.0
	People	talking background	17	16.3	5	17.2
	People	talking conversation	10	9.6	4	13.8
	People	talking loudly	5	4.8	1	3.4
	People	talking on phone	3	2.9	0	0.0
	People	whistling	2	1.9	0	0.0
	Patient	breathing	0	0.0	4	13.8
	Patient	moaning	1	1.0	1	3.4
	Patient	screaming	5	4.8	0	0.0
	Patient	talking	1	1.0	2	6.9
		Total	**104**		**29**	
		Combined Total	**133**			
		Percentage contribition to source perception	**42.2**			
Occupational	Bin	open/closing	7	5.8	3	12.0
	Cleaning room	steralising	4	3.3	0	0.0
	Computer	keyboard	3	2.5	0	0.0
	Curtains	opening/closing	2	1.7	0	0.0
	Door	slamming	1	0.8	0	0.0
	Door	opening/closing	8	6.7	0	0.0
	Draw	opening/closing	2	1.7	0	0.0
	Equipment	hissing	1	0.8	0	0.0
	Equipment	squeaking	2	1.7	0	0.0
	File	closing/clipping	4	3.3	0	0.0
	Floor cleaner	polisher	1	0.8	0	0.0
	Floor cleaner	buffer	1	0.8	2	8.0
	Trolley	passing	8	6.7	0	0.0
	Trolley	rattling	11	9.2	3	12.0
	Phone	ringing	11	9.2	2	8.0
	Object	banging	16	13.3	3	12.0
	Object	cup etc jingling	13	10.8	2	8.0
	Object	dropping	4	3.3	2	8.0
	Object	moving	6	5.0	1	4.0
	Object	ripping sound	2	1.7	1	4.0
	Object	rustling sound	10	8.3	4	16.0
	Tap	running water	2	1.7	2	8.0
	Wheelchair	moving	1	0.8	0	0.0
		Total	**120**		**25**	
		Combined Total	**145**			
		Percentage contribition to source perception	**46.0**			
Other	Object	moving heavy/hard objects	1	33.3	0	0.0
	TV	TV sound	2	66.7	0	0.0
		Total	**3**		**0**	
		Combined Total	**3**			
		Percentage contribition to source perception	**1.0**			
Medical	Monitor	beeping	10	76.9	4	21.1
	Monitor	fast beeping	1	7.7	3	15.8
	Monitor	long beep	1	7.7	5	26.3
	Equipment	Moving trolley	0	0.0	2	10.5
	Equipment	electric sound	0	0.0	1	5.3
	Equipment	fast beeping	1	7.7	0	0.0
	Equipment	high pitch beep	0	0.0	2	10.5
	Equipment	ripping sound	0	0.0	2	10.5
		Total	**13**		**19**	
		Combined Total	**32**			
		Percentage contribition to source perception	**10.2**			
External sound	Outside	car alarm	0	0.0	1	50.0
	Outside	car passing	0	0.0	1	50.0
		Total	**0**	**0**	**2**	
		Combined Total	**2**			
		Percentage contribition to source perception	**0.6**			

APPENDIX 3: UNDERSTANDING PERCEPTION USING LISTENING EVALUATIONS

3.1. Participant information sheet and consent for as approved by the University of Warwick BioMedical Research Ethics Committee.



International Digital Laboratory
University of Warwick
Coventry CV4 7AL

Dear Sir/Madam,

I am writing to invite you to participate in a doctoral research project carried out by James Mackrill based at the University of Warwick. The project, named "what is a positive healthcare soundscape and how can it be achieved?" aims to understand the role sound plays within healthcare environments by exploring the sounds that people hear within them.

I would like to invite you to participate in a listening evaluation of hospital sounds. This will be held at the International Digital Laboratory at the University of Warwick. You will be played different sound recorded from a hospital and asked to rate how it makes you feel. This should last no longer than 40 minutes.

All information will be anonymous and you will not be asked to give your name or any identifiable personal details. If you decide to take part you are entitled to withdraw at any time without reason.

Please find attached the information sheet giving more details. If you would like to take part or require any further information please contact me on the details provided.

Yours sincerely,

James Mackrill

Research Student
WMG,
University of Warwick

Email: j.b.mackrill@warwick.ac.uk
Mobile: +44 (0)78 4181 8227
Tel: +44 (0)24 7615 076

University Hospitals Coventry and Warwickshire NHS Trust
WMG Innovative Solutions
WARWICK IMRC
THE UNIVERSITY OF WARWICK

Participant information Sheet

Study title

Project Title:
Establishing and testing the emotional dimensions of the healthcare soundscape.

Lay Summary:

The study aims to understand how the healthcare soundscape (the sounds that people hear in a hospital) makes people feel. This is the experimental stage of a research project undertaken as a doctoral qualification within Warwick Manufacturing Group (WMG) at the University of Warwick entitled "what is a positive healthcare soundscape and how can it be achieved?" Initial data collection was conducted at University Hospital, Coventry (ref: 10/H2106/16) which interviewed patients and nurses about their thoughts on the soundscape within a cardio-thoracic ward.

Currently there is little research looking at improving sound within healthcare spaces through understanding the perception of them. Recent research addresses this through sound level measurement and mitigation methods. Simply, the project aims to improve the sounds people hear in hospital by understanding how they make people feel and how they can be made to make people feel more positive.

To help answer this listening evaluations are being held. In the evaluation various sounds from a hospital ward will be played and how these sounds make people feel will be recorded. This will then show what hospital sounds make people feel positive and what make them feel negative. Using this method means interventions, such as changing sounds, adding sound in can be tested to see if this is more positive or negative.

The study asks how the sounds make you feel, therefore recording the emotional response to them. Words will be given which the soundscape can be rated against.

If you are interested in participating in this research study, please read on.

University Hospitals Coventry and Warwickshire NHS Trust

WMG Innovative Solutions

Warwick IMRC ...making a difference

The University of Warwick

Invitation paragraph

I would like to invite you to participate in my research study. Before you decide if you would like to participate I want you to understand why the research is being done and what it involves. This should take about 10 minutes to read to decide if you would like to participate or need more information.

Ask if there is anything that is not clear. My contact details are:

Name: James Mackrill
Email: j.b.mackrill@warwick.ac.uk
Telephone Number: 024761 50760
Mobile Number: 07841818227

What is the study about?

I am a doctoral student within Warwick Manufacturing Group (WMG) at the University of Warwick. The purpose of the study is to understand the perception of the hospital soundscape (all sounds you hear in a hospital). My research is looking at how the soundscape makes people feel and how it can be changed to make them feel more positive. To do this I am carrying out listening evaluations in which people rate how the sounds of the hospital make them feel.

Why have I been invited?

You have been invited as I want to understand people's response to the healthcare soundscape and you have shown an interest in being involved. There will be 60 people also participating in the study but not at the same time.

Do I have to take part?

Taking part is entirely voluntary and you should read the information sheet about what it involves. If you agree to take part you will be asked to sign a consent form agreeing to your participation in the study but you may withdraw at anytime.

What will happen to me if I take part?

The study involves a listening evaluation. This will be held in the SoundRoom laboratory in the International Digital Laboratory at the University of Warwick. In the evaluation you will be asked to think about the sounds you would hear in hospital and then be played various sounds from around a hospital. When you are listening to the different sound clips you will then be asked to rate how this makes you feel. All the sound recordings are from an actual hospital but some may have sounds added in to change the perception of them. The total evaluation should last no longer than 40 minutes.

All information will be anonymous and you will only be asked to give your age, gender and if you are a healthcare professional or not.

The results from the evaluation will be used to make a tool which can assess and benchmark how soundscape within a particular hospital space e.g. intensive care, accident and emergency, makes people feel. This will be used to write academic papers and in the final thesis.

University Hospitals NHS
Coventry and Warwickshire
NHS Trust

WMG
Innovative Solutions

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WARWICK

Expenses and payments

There are no expenses or payments associated with being involved in the research.

What are the possible disadvantages and risks of taking part?

There are very little risks associated with the research and the main disadvantage is that it will take around 40 minutes of your time.

What are the possible benefits of taking part?

The advantages are that you will be involved in research that will improve the understanding of the healthcare soundscape and that could potentially improve healthcare environments and the information we get from this study may benefit others in the future. It is hoped you will find the experience interesting.

What if I want more information about the study?

If you have any questions about any aspect of the study or your participation in it please contact either: James Mackrill, Professor Paul Jennings or Dr Rebecca Cain.

Chief Investigator	**Academic Supervisors**	
James Mackrill	**Professor Paul Jennings**	**Dr Rebecca Cain**
International Digital Laboratory University of Warwick Coventry CV4 7AL	International Digital Laboratory University of Warwick Coventry CV4 7AL	International Digital Laboratory University of Warwick Coventry CV4 7AL
Email: j.b.mackrill@warwick.ac.uk	Email: Paul.Jennings@warwick.ac.uk	Email: R.Cain.1@warwick.ac.uk
Tel: +44 (0)24 761 50760	Tel: +44 (0)24 765 2364	Tel: +44 (0)24 765 75951
Mobile: +44 (0)78 4181 8227		

What if there is a problem and who should I contact if I wish to make a complaint?

If there is a problem with the research the University has in force a Public and Products Liability policy which provides cover for claims for "negligent harm" and the activities here are included within that coverage subject to the terms, conditions and exceptions of the policy.

Any complaint about the way you have been dealt with during the study or any possible harm you might have suffered will be addressed. Please address your complaint to the person below who is a senior university official entirely independent of the study:

Nicola Owen
Deputy Registrar Deputy Registrar's Office University of Warwick Coventry CV4 8UW
Email: Nicola.Owen@warwick.ac.uk
Tel: 024 7652 2785

Will my taking part in the study be kept confidential?

Yes. All information which is collected about you during the course of the research will be kept strictly confidential, and any information will be kept within a locked filing cabinet in the office at the International Digital Laboratory. You will only be asked to provide basic information (age, gender, if you are a healthcare professional) and you name will not be taken.

During the study data will be stored within a locked filing cabinet and on university owned computers which required a user name and password by James Mackrill. This data will be accessed only by James Mackrill and academic supervisors Professor Paul Jennings and Dr Rebecca Cain. After the study the data will be kept for 2 year until the PhD has been completed and passed after which it will be destroyed.

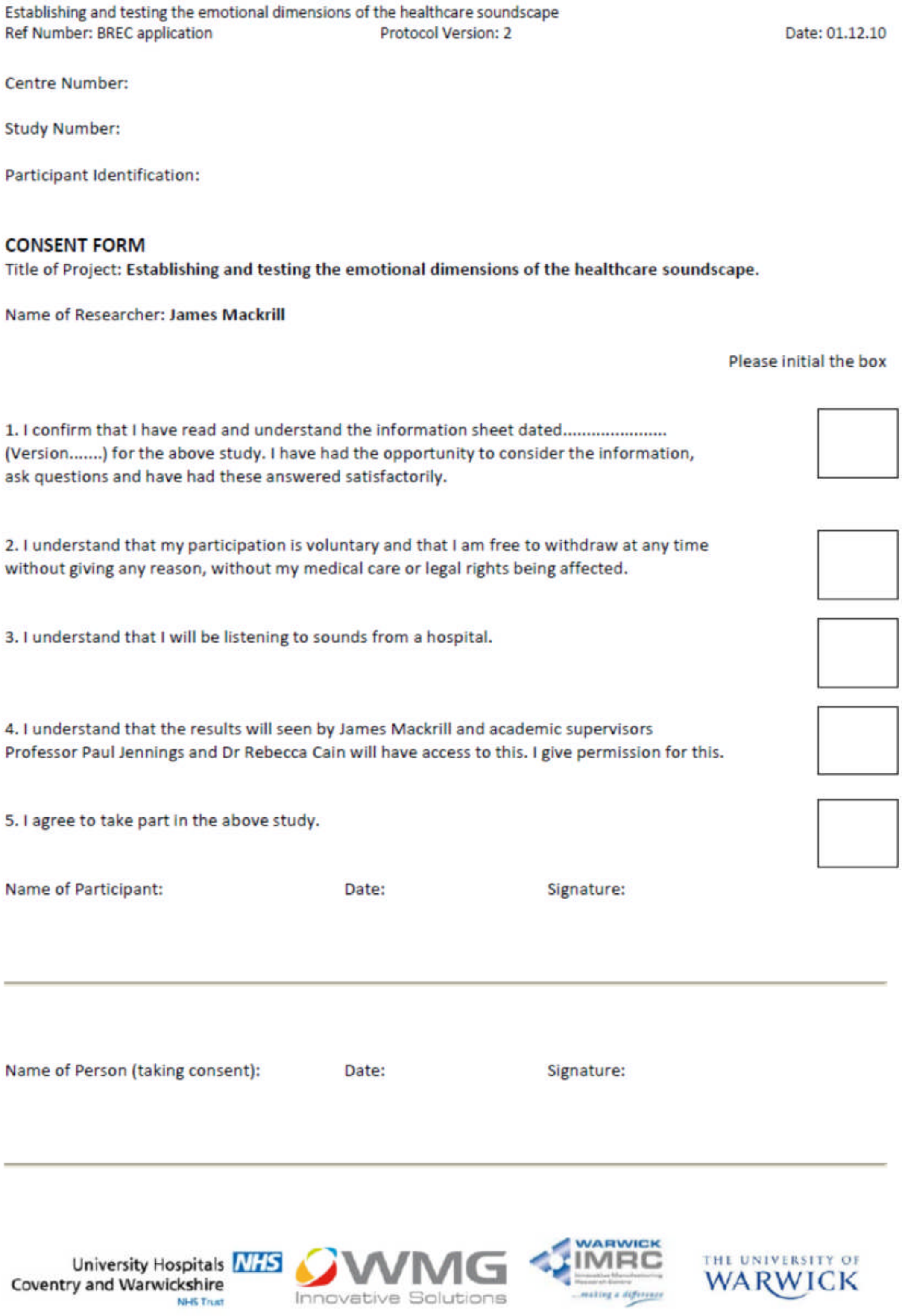
It will not be possible to identify you from any published material arising from the study as anonymity will be ensured as all participants will be given a participant identification number.

What will happen if I don't want to carry on with the study?
If you do not wish to carry on with the study at anytime you can withdraw without reason. Any data you have provided will be destroyed as only completed evaluation sheets will be used in the analysis of the results.

What will happen to the results of the research study?
The results of the study will be written up and presented within academic papers and at conferences. The results will be used within the final PhD thesis. All data collected will be used but no individual data will be specifically displayed, only the generic findings.

Who is organising and funding the research?
The PhD is funded by the Engineering and Physical Sciences Research Council (EPSRC) through the Warwick Innovative Manufacturing Research Centre (WIMRC) based within Warwick Manufacturing Group (WMG) at the University of Warwick. Therefore the University of Warwick is the sponsor of the research.

Who has reviewed the study?
All research is checked by a research ethics committee. This study has been reviewed and given favourable opinion by the University of Warwick's Biomedical Research Ethics Committee.



Establishing and testing the emotional dimensions of the healthcare soundscape
Ref Number: BREC application Protocol Version: 2 Date: 01.12.10

Centre Number:

Study Number:

Participant Identification:

CONSENT FORM

Title of Project: **Establishing and testing the emotional dimensions of the healthcare soundscape.**

Name of Researcher: **James Mackrill**

Please initial the box

1. I confirm that I have read and understand the information sheet dated..................... (Version.......) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. ☐

3. I understand that I will be listening to sounds from a hospital. ☐

4. I understand that the results will seen by James Mackrill and academic supervisors Professor Paul Jennings and Dr Rebecca Cain will have access to this. I give permission for this. ☐

5. I agree to take part in the above study. ☐

Name of Participant: Date: Signature:

Name of Person (taking consent): Date: Signature:

3.2. Response sheet for Study B1 semantic validation. *Note*, not actual size.

Hospital Soundscape Evaluation Instructions

This evaluation is interested in understanding how the sounds of a hospital make people feel. To do this imagine you were in a hospital. Think about the sounds you might hear, what you would expect to hear, what you might notice and how you would feel.

Twenty one sound clips from a hospital will be played to you. These each last 45 seconds with a 20 second break between them. When the sounds are played you will be asked to down words which describe how the sounds make you feel. Try not to describe the sounds you hear but how they make you feel.

A bit about you

Gender: Male Female

Age: ....

Are you a healthcare professional? Yes No

If yes, what is your job title? ....

If you would like to be informed of the results via email please provide your email address below.

Contact email: ....

A sound clip will now be played. This is **not** part of the evaluation but a practice so you understand the procedure. Please look at the example and then answer the practice questions.

Example

Listen to the sounds. How do they make you feel?

Please write down all the words you can think of which describe how the hospital sounds make you feel.

Unruffled
Serene
Tense
Upset

Practice

Please turn over and complete the practice evaluation. Listen to the sounds now and rate how they make you feel this is a practise.

If you have any questions please ask.

PRACTICE **Listen to the sounds. How do they make you feel?**

Please write down all the words you can think of which describe how the sounds make you feel.

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

The evaluation will now start. When you hear the next sounds please turn over.

Listen to the sounds. How do they make you feel?

Please write down all the words you can think of which describe how the sounds make you feel.

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

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……………………………………………………………………

……………………………………………………………………

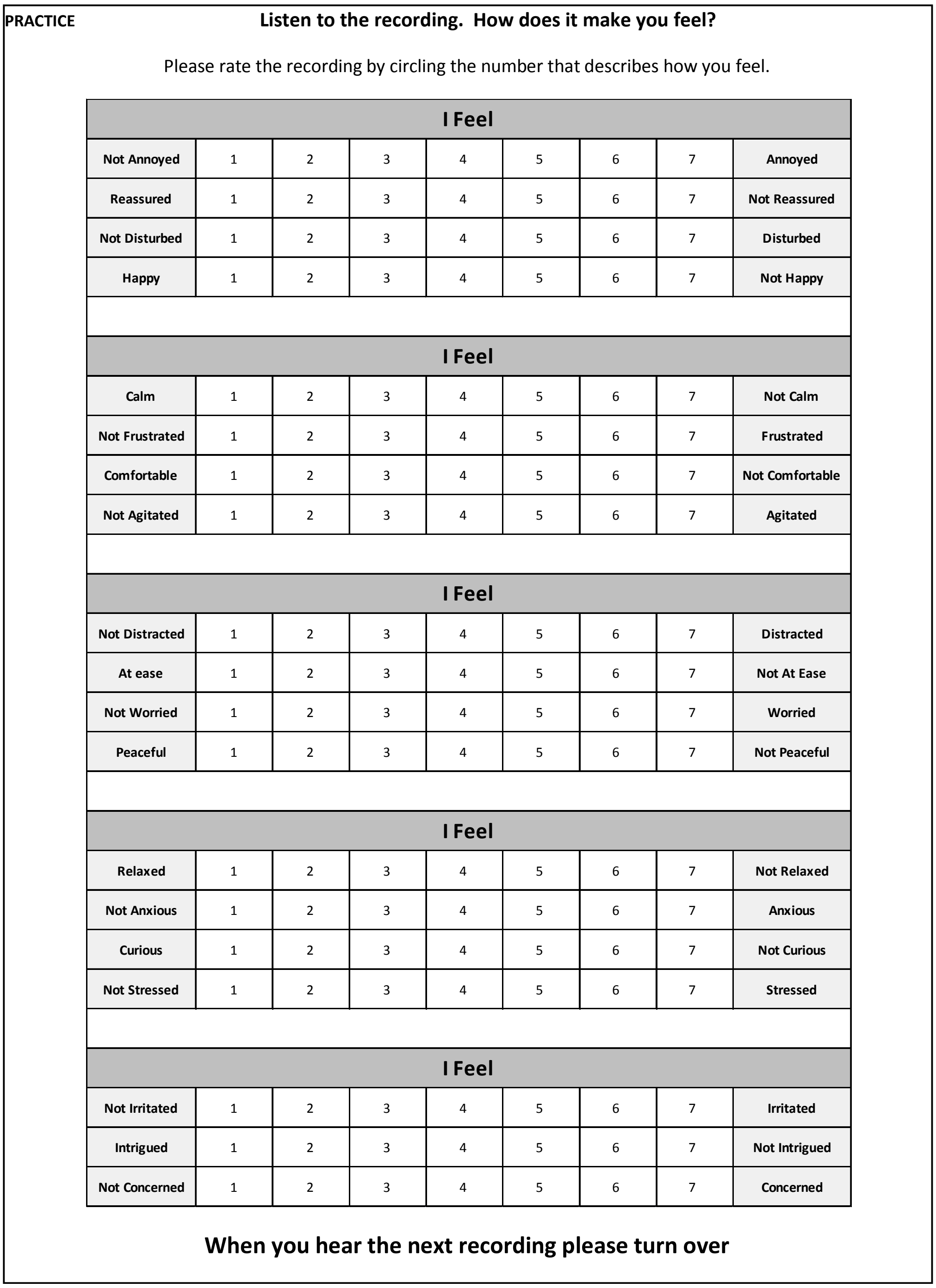
……………………………………………………………………

When you hear the next sounds please turn over.

3.3. Table showing latin square randomisation for the presentation order of each clip to participants. *Note,* clip 1 and 20 are the same all participants receiving clip1 as practice.

Recording number	**Recording number**	**Recording number**	**Recording number**	**Recording number**
Start sequence for participants 1-4	*Start sequence for participants 5-8*	*Start sequence for participants 9-12*	*Start sequence for participants 13-16*	*Start sequence for participants 16-18*
1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20

3.4. Pilot listening evaluation response sheet using Ishihara (2010) denial word format.



PRACTICE

Listen to the recording. How does it make you feel?

Please rate the recording by circling the number that describes how you feel.

I Feel								
Not Annoyed	1	2	3	4	5	6	7	**Annoyed**
Reassured	1	2	3	4	5	6	7	**Not Reassured**
Not Disturbed	1	2	3	4	5	6	7	**Disturbed**
Happy	1	2	3	4	5	6	7	**Not Happy**

I Feel								
Calm	1	2	3	4	5	6	7	**Not Calm**
Not Frustrated	1	2	3	4	5	6	7	**Frustrated**
Comfortable	1	2	3	4	5	6	7	**Not Comfortable**
Not Agitated	1	2	3	4	5	6	7	**Agitated**

I Feel								
Not Distracted	1	2	3	4	5	6	7	**Distracted**
At ease	1	2	3	4	5	6	7	**Not At Ease**
Not Worried	1	2	3	4	5	6	7	**Worried**
Peaceful	1	2	3	4	5	6	7	**Not Peaceful**

I Feel								
Relaxed	1	2	3	4	5	6	7	**Not Relaxed**
Not Anxious	1	2	3	4	5	6	7	**Anxious**
Curious	1	2	3	4	5	6	7	**Not Curious**
Not Stressed	1	2	3	4	5	6	7	**Stressed**

I Feel								
Not Irritated	1	2	3	4	5	6	7	**Irritated**
Intrigued	1	2	3	4	5	6	7	**Not Intrigued**
Not Concerned	1	2	3	4	5	6	7	**Concerned**

When you hear the next recording please turn over

3.5. Table showing semantics pairs used in the listening evaluation. *Note,* positive pairs, and negative pairs shown respectively.

Positive semantic	**Response frequency count for evaluation (demotes combined frequency with interviews)**	**Negative semantic (antonym)**	**Bipolar semantic pair used in**	**Bipolar semantic scale derived from study**
Calm	52 (63)	Agitated	(Cain, et al., 2009; Kang & Zhang, 2010)	Yes
Relaxed	16 (26)	Stressed	(Cain, et al., 2009)	Yes
Reassured	14 (15)	Worried	(Cain, et al., 2009)	Yes
At ease	10	Anxious		Yes
Intrigued	9	Bored		Yes
Comfortable	7	Uncomfortable 16 (17)*		Yes
Curious	7	Apathetic		No, Oxford English Dictionary (2005)
Alert	6	Unprepared		No, Oxford English Dictionary (2005)
Annoyed	52 (60)*	Content	(Russell, 1980)	No (Russell, 1980)
Peaceful	6	Troubled	(Axelsson, et al., 2010)	No, (Axelsson, et al., 2010)
Distracted	41	Attentive		No, Oxford English Dictionary (2005)
Irritated	19 (22)*	Tolerant		No, Oxford English Dictionary (2005)
Frustrated	18	Satisfied	(Russell, 1980)	No, (Russell, 1980)
Disturbed	17 (19)*	Undisturbed		No, Kansei denial terms (Ishihara, 2010)
Concerned	13	Unconcerned		No, Kansei denial terms (Ishihara, 2010)

3.6. Table showing definition of key semantics. *Note,* red marks words not obtained from interviews/evaluation.

Word	**Definitions** *(Oxford English dictionary)*	**Antonym**
Alert	Vigilantly attentive	Unprepared
Angry	Feeling or expression of annoyance; animosity; or resentment.	Calm
Annoy(ed)	Irritate or displease	Pleased
Anxious	Worried or tense because of possible misfortune; unease.	At ease
Bored	A dull repetitious or uninterested person, activity, or state.	Interested
Calm	Not disturbed, anxious, excited; tranquil, serene	Agitated
Comfortable	At ease, without affection or pain.	Uncomfortable
Concerned	Worried, troubled.	Unconcerned
Confused	Feelings or exhibiting an inability to understand; bewildered; perplexed.	Enlightened
Distracted	To draw the attention (of a person) away (divide or confuse the attention); bewildered; confused.	Attentive
Disturb(ed)	To intrude on; interrupt; upset or agitate; trouble.	Unconcerned
Encourage(d)	*To inspire, stimulate*	
Frustrated	Having feelings of dissatisfaction or lack of fulfilment.	Calm?
Happy	Feeling, expression, showing joy.	Sad
Irritated	To annoy or anger	
Peaceful	Absence of mental anxiety; state of stillness, silence, or serenity.	Worried
Reassure(d)	To relieve someone of anxieties; restore confidence.	Worried
Reflective	Characterised by quiet thought or contemplation	Shallow
Stress(ed)	Mental, emotional, physical strain or tension.	Relaxed
Uncomfortable	Not comfortable; feeling or causing discomfort or unease; disquieting.	Comfortable
Unconcerned	Lacking in concern or involvement, not worried; untroubled	
Curious	Eager to know; inquisitive	Apathetic
Intrigued	Interested or curious	
Relaxed	Free from tension, anxiety and stress	Stressed

3.7. Table showing Latin square method used to randomise the semantic pair presentation order for the evaluation response sheet.

Scale Cluster 1		Scale Cluster 2		Scale Cluster 3		Scale Cluster 4		Scale Cluster 5	
1	Calm	2	Relaxed	3	Reassured	4	At Ease	5	Intrigued
6	Comfortable	7	Curious	8	Alert	9	Peaceful	10	Content
11	Attentive	12	Tolerant	13	Satisfied	14	Undisturbed	15	Unconcerned

3.8. Response questionnaire sheet use Study B2 listening evaluation.

Soundscape Evaluation Instructions

I am interested in understanding how people feel when they hear sounds in a hospital. To do this imagine you were a patient / healthcare professional on a hospital ward. Think about the sounds you might hear, what you would expect to hear, what you might notice and **how you would feel**.

A number of sound clips from a hospital will be played to you. These each last around 20 seconds repeated 4 times with a 20 second break between them. When the recording is played you will be asked to rate it according to words which **describe how you might feel**. Rate on the semantic scale the number which closest represents how you feel based on the two words on the scale (see example). The words were chosen on the basis of discussions with real patients and nurses, and also from previous listening evaluations. There are 15 scales on each page.

Please look at the example and then turn over to complete the practice questions.

Example

Listen to the recording. How does it make you feel?

Please rate all the scales by circling the number that describes how you feel.

I Feel								
Worried	1	2	3	4	[✓ 5]	6	7	**Reassured**
Unprepared	1	2	3	4	5	6	[✓ 7]	**Alert**
Frustrated	1	2	[✓ 3]	4	5	6	7	**Satisfied**

Practice

Please turn over and complete the practice questions. Listen to the recordings and rate how they make you feel. This is a practice.

If you have any questions please ask.

Listen to the recording. How does it make you feel?

Please rate the recording by circling the number that describes how you feel.

I Feel								
Agitated	1	2	3	4	5	6	7	Calm
Uncomfortable	1	2	3	4	5	6	7	Comfortable
Distracted	1	2	3	4	5	6	7	Attentive
I Feel								
Stressed	1	2	3	4	5	6	7	Relaxed
Apathetic	1	2	3	4	5	6	7	Curious
Irritated	1	2	3	4	5	6	7	Tolerant
I Feel								
Worried	1	2	3	4	5	6	7	Reassured
Unprepared	1	2	3	4	5	6	7	Alert
Frustrated	1	2	3	4	5	6	7	Satisfied
I Feel								
Anxious	1	2	3	4	5	6	7	At ease
Troubled	1	2	3	4	5	6	7	Peaceful
Disturbed	1	2	3	4	5	6	7	Undisturbed
I Feel								
Bored	1	2	3	4	5	6	7	Intrigued
Annoyed	1	2	3	4	5	6	7	Content
Concerned	1	2	3	4	5	6	7	Unconcerned

When you hear the next recording please turn over

A bit about you

Gender: Male Female (please circle)

Age: ....

Are you a healthcare professional? Yes No (please circle)

What is your job title? ....

Have you been in a hospital in the past year? Yes No (please circle)

If you would like to be informed of the results please provide your email address below.

Contact email: ....

Some questions about the evaluation.

Did you find the questions easy or difficult to answer? Explain why.

Do you have any comments about the design of the questionnaire?

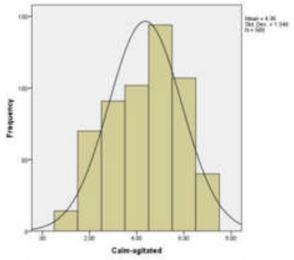
Do you have any comments about the hospital recordings?

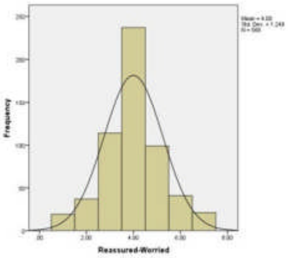
Thank you for your time completing the evaluation.

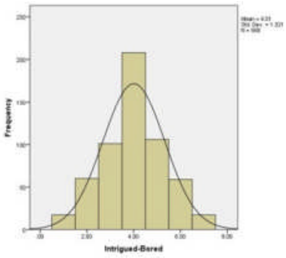
3.9. Distribution for all 15 semantic scales. *Note,* Histograms show normal distribution shown despite the variation in z-scores beyond the 1.96 parameters. This was attributed to the large sample of data collected meaning this test was more sensitive. Skewness statistic is <1.0 on all scales.

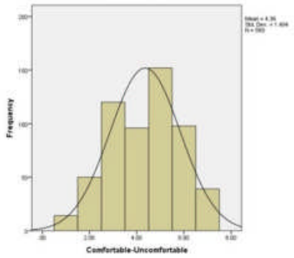
Descriptive Statistics

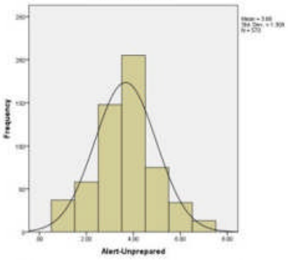
	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis		Distribution (z-score)
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error	Skewness / Skewness S.E.
Calm-Agitated	568	6.00	1.00	7.00	4.3609	.06486	1.54590	2.390	-.212	.103	-.828	.205	-2.07
Comfortable-Uncomfortable	569	6.00	1.00	7.00	4.3568	.06265	1.49446	2.233	-.155	.102	-.743	.204	-1.51
Attentive-Distracted	569	6.00	1.00	7.00	4.8348	.06406	1.52818	2.335	-.664	.102	-.135	.204	-6.49
Relaxed-Stressed	569	6.00	1.00	7.00	4.3040	.06275	1.49671	2.240	-.225	.102	-.682	.204	-2.20
Curious-Apathetic	568	6.00	1.00	7.00	3.7958	.05770	1.37521	1.891	.253	.103	-.186	.205	2.47
Tolerant-Irritated	570	6.00	1.00	7.00	4.4579	.06979	1.66610	2.776	-.305	.102	-.892	.204	-2.98
Reassured-Worried	568	6.00	1.00	7.00	3.9982	.05242	1.24934	1.561	.069	.103	.424	.205	0.67
Alert-Unprepared	570	6.00	1.00	7.00	3.6614	.05485	1.30946	1.715	.079	.102	.127	.204	0.77
Satisfied-Frustrated	568	6.00	1.00	7.00	4.4701	.05565	1.32636	1.759	-.277	.103	-.119	.205	-2.70
At ease - Anxious	570	6.00	1.00	7.00	4.0895	.06538	1.56097	2.437	-.071	.102	-.686	.204	-0.70
Peaceful-Troubled	569	6.00	1.00	7.00	4.4236	.05947	1.41852	2.012	-.286	.102	-.416	.204	-2.80
Undistrubed-Disturbed	569	6.00	1.00	7.00	4.7452	.06934	1.65409	2.736	-.617	.102	-.339	.204	-6.03
Intrigued-Bored	568	6.00	1.00	7.00	4.0053	.05542	1.32070	1.744	-.014	.103	-.166	.205	-0.14
Content-Annoyed	570	6.00	1.00	7.00	4.5474	.06076	1.45054	2.104	-.296	.102	-.456	.204	-2.89
Unconcerned-Concerned	570	6.00	1.00	7.00	3.7754	.06862	1.63832	2.684	.066	.102	-.705	.204	0.64
Valid N (listwise)	560												

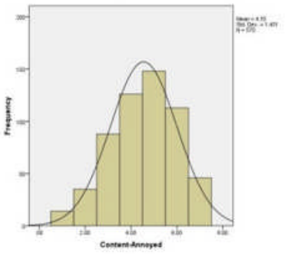

Frequency
.00
2.00
4.00
6.00
8.00
Calm-agitated

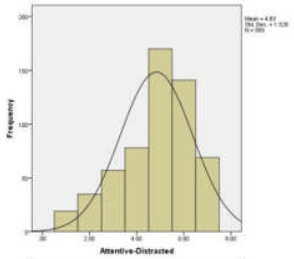

Frequency
.00
2.00
4.00
6.00
8.00
Reassured-Worried

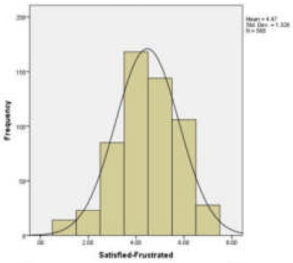

Frequency
.00
2.00
4.00
6.00
8.00
Intrigued-Bored

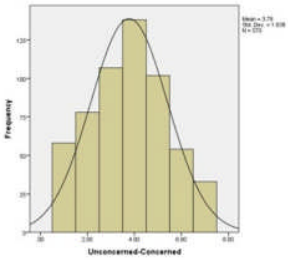

Frequency
.00
2.00
4.00
6.00
8.00
Comfortable-Uncomfortable

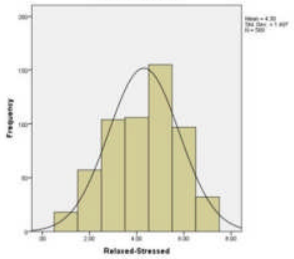

Frequency
.00
2.00
4.00
6.00
8.00
Alert-Unprepared

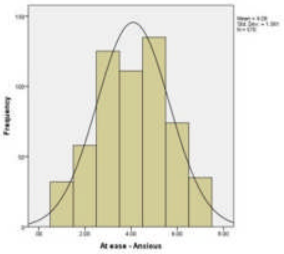

Frequency
.00
2.00
4.00
6.00
8.00
Content-Annoyed

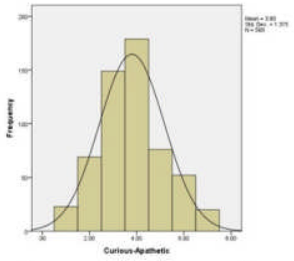

Frequency
.00
2.00
4.00
6.00
8.00
Attentive-Distracted

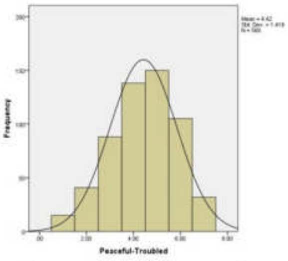

Frequency
.00
2.00
4.00
6.00
8.00
Satisfied-Frustrated

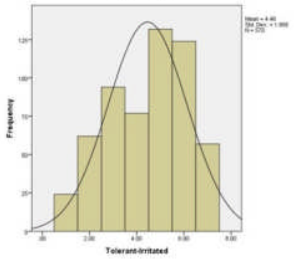

Frequency
.00
2.00
4.00
6.00
8.00
Unconcerned-Concerned

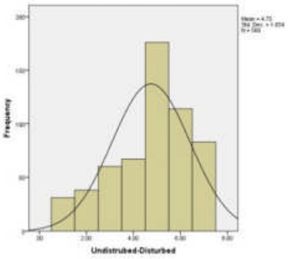

Frequency
.00
2.00
4.00
6.00
8.00
Relaxed-Stressed


Frequency
.00
2.00
4.00
6.00
8.00
At ease - Anxious


Frequency
.00
2.00
4.00
6.00
8.00
Curious-Apathetic

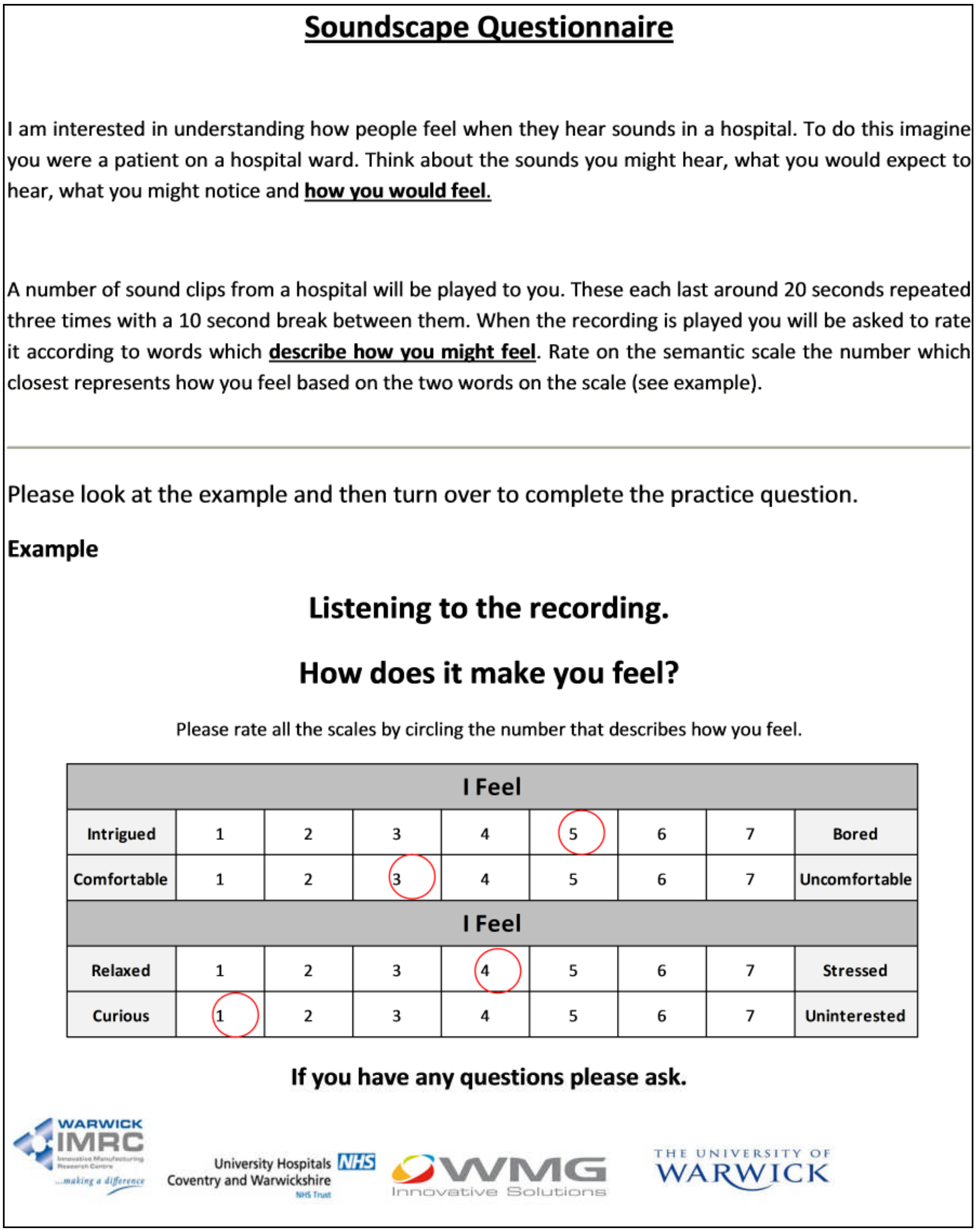

Frequency
.00
2.00
4.00
6.00
8.00
Peaceful-Troubled


Frequency
.00
2.00
4.00
6.00
8.00
Tolerant-Irritated


Frequency
.00
2.00
4.00
6.00
8.00
Undistrubed-Disturbed

APPENDIX 4: Soundscape Interventions

4.1. Response sheet used in Study C1 for conditions control, natural and steady state sound interventions.



Soundscape Questionnaire

I am interested in understanding how people feel when they hear sounds in a hospital. To do this imagine you were a patient on a hospital ward. Think about the sounds you might hear, what you would expect to hear, what you might notice and **how you would feel**.

A number of sound clips from a hospital will be played to you. These each last around 20 seconds repeated three times with a 10 second break between them. When the recording is played you will be asked to rate it according to words which **describe how you might feel**. Rate on the semantic scale the number which closest represents how you feel based on the two words on the scale (see example).

Please look at the example and then turn over to complete the practice question.

Example

Listening to the recording.

How does it make you feel?

Please rate all the scales by circling the number that describes how you feel.

I Feel								
Intrigued	1	2	3	4	[✓ 5]	6	7	**Bored**
Comfortable	1	2	[✓ 3]	4	5	6	7	**Uncomfortable**
I Feel								
Relaxed	1	2	3	[✓ 4]	5	6	7	**Stressed**
Curious	[✓ 1]	2	3	4	5	6	7	**Uninterested**

If you have any questions please ask.

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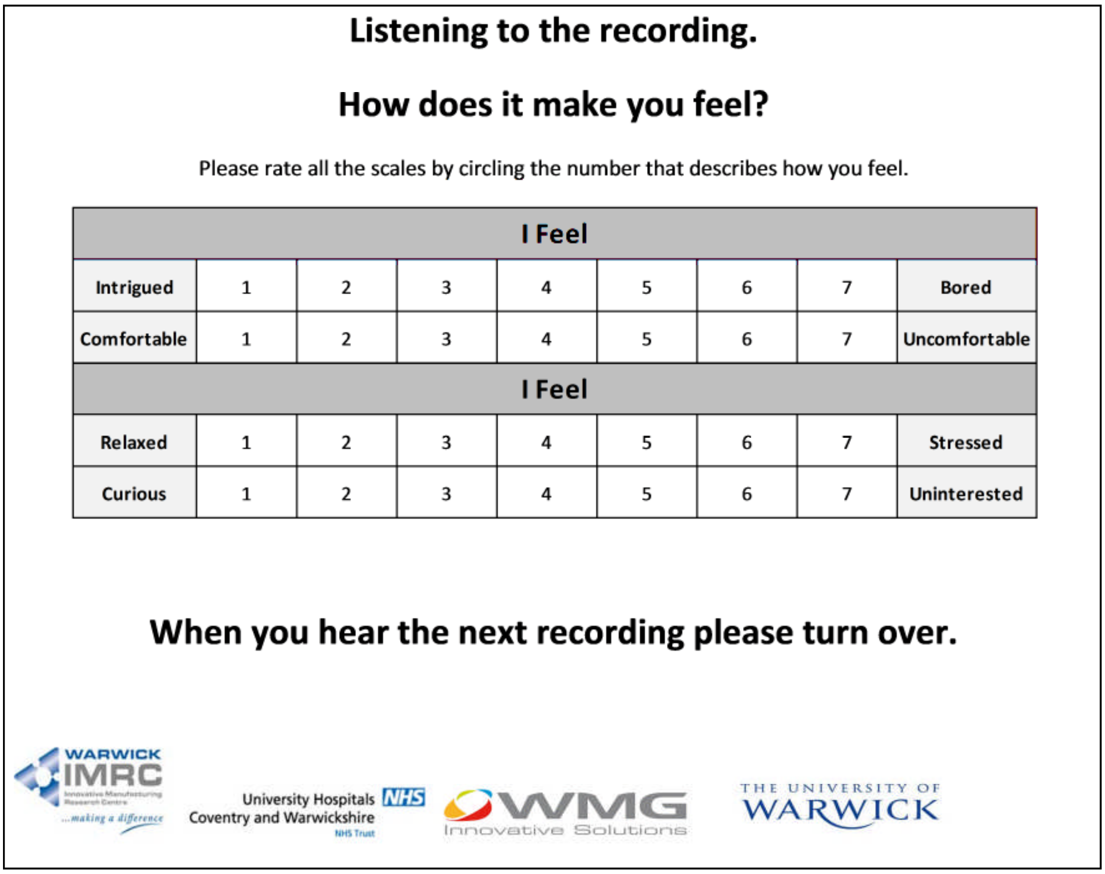


Listening to the recording.

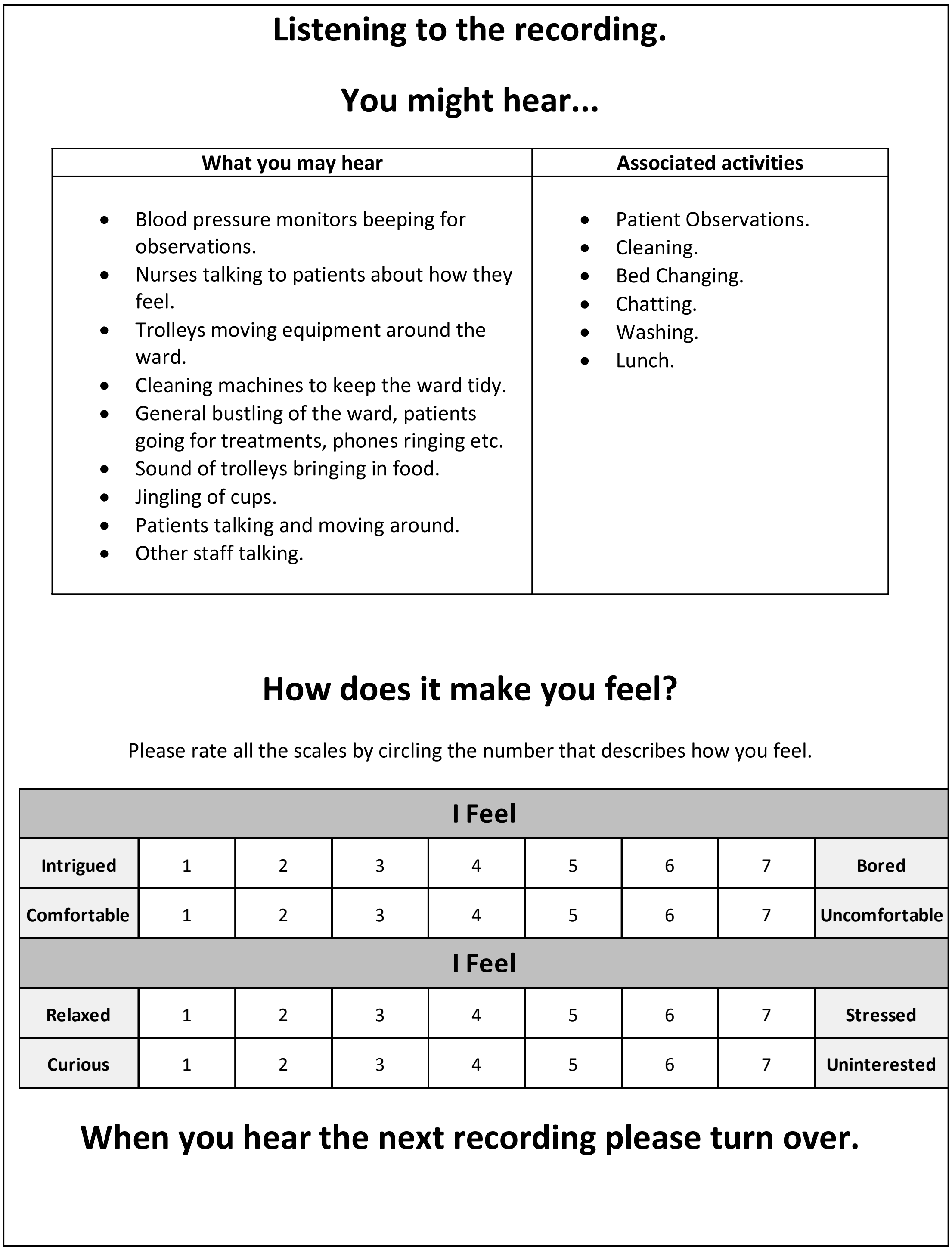
How does it make you feel?

Please rate all the scales by circling the number that describes how you feel.

I Feel								
Intrigued	1	2	3	4	5	6	7	**Bored**
Comfortable	1	2	3	4	5	6	7	**Uncomfortable**
I Feel								
Relaxed	1	2	3	4	5	6	7	**Stressed**
Curious	1	2	3	4	5	6	7	**Uninterested**

When you hear the next recording please turn over.

4.2. Response sheet used in Study C1 for sound source information intervention.



Listening to the recording.

You might hear...

What you may hear	Associated activities
• Blood pressure monitors beeping for observations. • Nurses talking to patients about how they feel. • Trolleys moving equipment around the ward. • Cleaning machines to keep the ward tidy. • General bustling of the ward, patients going for treatments, phones ringing etc. • Sound of trolleys bringing in food. • Jingling of cups. • Patients talking and moving around. • Other staff talking.	• Patient Observations. • Cleaning. • Bed Changing. • Chatting. • Washing. • Lunch.

How does it make you feel?

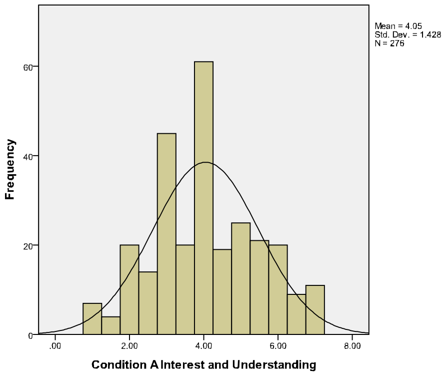
Please rate all the scales by circling the number that describes how you feel.

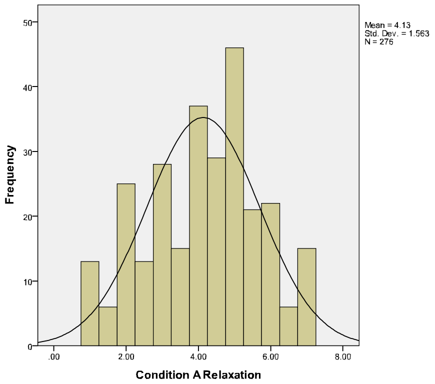
I Feel								
Intrigued	1	2	3	4	5	6	7	**Bored**
Comfortable	1	2	3	4	5	6	7	**Uncomfortable**
I Feel								
Relaxed	1	2	3	4	5	6	7	**Stressed**
Curious	1	2	3	4	5	6	7	**Uninterested**

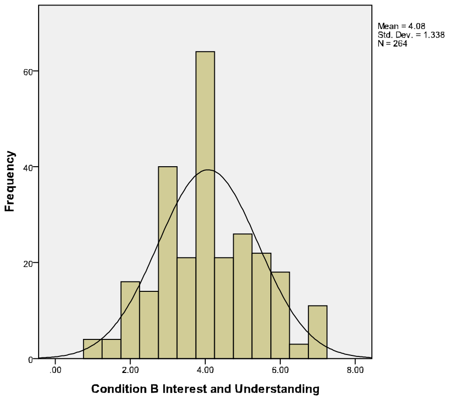
When you hear the next recording please turn over.

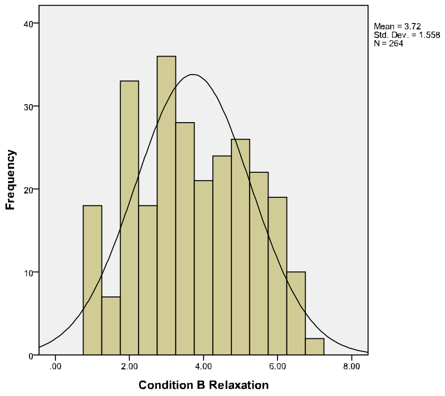
4.3. Normality test for dimensions scores across all conditions. ***Note,*** **Histograms shown on following page. All skewness statistics < 1.0 and all z-scores < 1.96.**

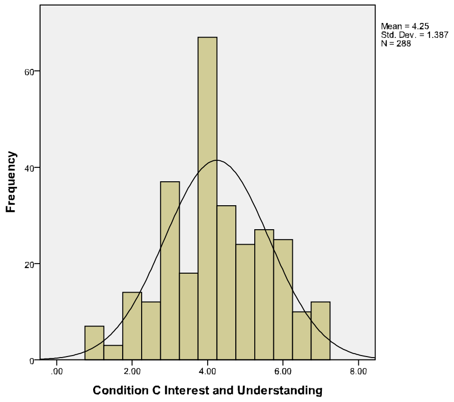
Descriptive Statistics											
	N	Minimum	Maximum	Mean		Std. Deviation	Skewness		Kurtosis		Distribution (z-score)
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error	Statistic	Std. Error	skewness/skewness SE
Condition A Interest	277	.00	7.00	4.0379	.08690	1.44632	.072	.146	-.412	.292	0.49
Condition A Relaxation	277	.00	7.00	4.1191	.09490	1.57950	-.217	.146	-.626	.292	-1.48
Condition B Interest	265	.00	7.00	4.0623	.08345	1.35851	.072	.150	-.172	.298	0.48
Condition B Relaxation	265	.00	7.00	3.7038	.09654	1.57152	.028	.150	-.920	.298	0.19
Condition C Interest	289	.00	7.00	4.2318	.08275	1.40679	-.116	.143	-.235	.286	-0.81
Condition C Relaxation	289	.00	7.00	3.9810	.09191	1.56252	-.246	.143	-.607	.286	-1.72
Condition D Interest	289	.00	7.00	4.1194	.08100	1.37706	.146	.143	-.218	.286	1.02
Condition D Relaxation	289	.00	7.00	3.9256	.08838	1.50249	-.106	.143	-.590	.286	-0.74
Valid N (listwise)	265										normal distribution

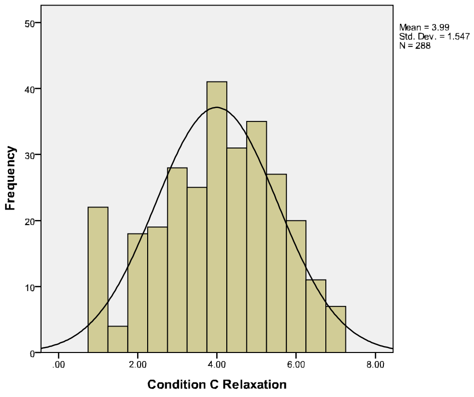

Mean = 4.05
Std. Dev. = 1.428
N = 276
Frequency
0
20
40
60
.00
2.00
4.00
6.00
8.00
Condition A Interest and Understanding

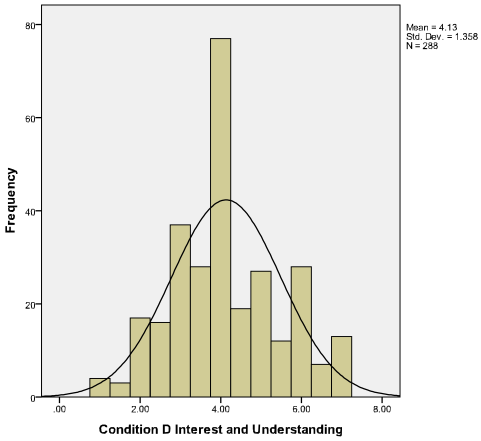

Mean = 4.13
Std. Dev. = 1.563
N = 276
Frequency
0
10
20
30
40
50
.00
2.00
4.00
6.00
8.00
Condition A Relaxation

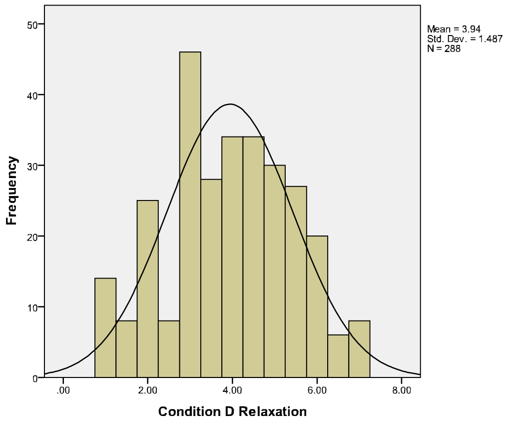

Mean = 4.08
Std. Dev. = 1.338
N = 264
Frequency
0
20
40
60
.00
2.00
4.00
6.00
8.00
Condition B Interest and Understanding


Mean = 3.72
Std. Dev. = 1.558
N = 264
Frequency
0
10
20
30
40
.00
2.00
4.00
6.00
8.00
Condition B Relaxation


Mean = 4.25
Std. Dev. = 1.387
N = 288
Frequency
0
20
40
60
.00
2.00
4.00
6.00
8.00
Condition C Interest and Understanding

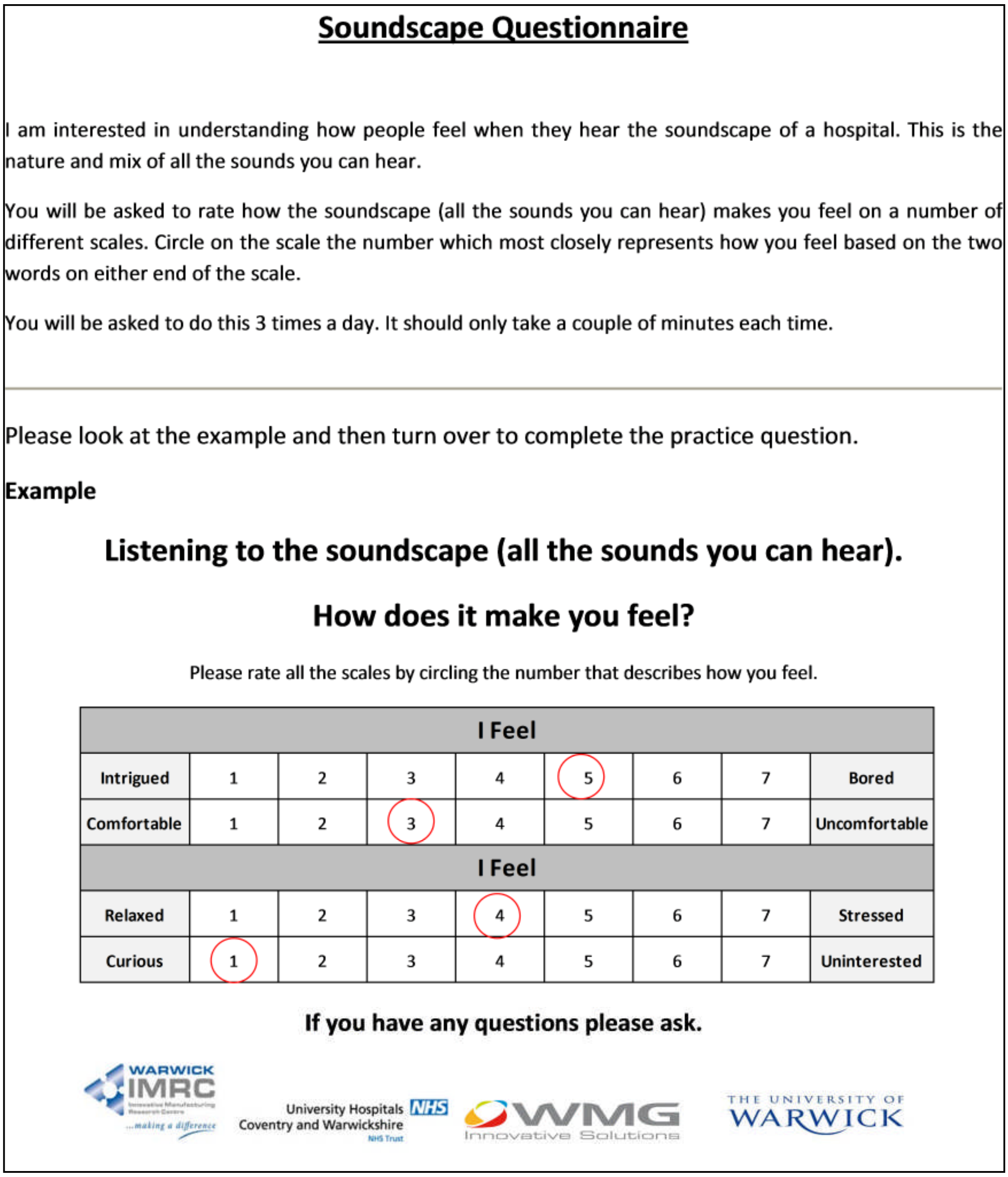

Mean = 3.99
Std. Dev. = 1.547
N = 288
Frequency
0
10
20
30
40
50
.00
2.00
4.00
6.00
8.00
Condition C Relaxation


Mean = 4.13
Std. Dev. = 1.358
N = 288
Frequency
0
20
40
60
80
.00
2.00
4.00
6.00
8.00
Condition D Interest and Understanding


Mean = 3.94
Std. Dev. = 1.487
N = 288
Frequency
0
10
20
30
40
50
.00
2.00
4.00
6.00
8.00
Condition D Relaxation

APPENDIX 5: Soundscape Interventions: In-situ Study C2

5.1. Questionnaire A (control). ***Note,*** **the same question layout used for the three time (9am, 12 noon, 4pm). Not actual size.**



Soundscape Questionnaire

I am interested in understanding how people feel when they hear the soundscape of a hospital. This is the nature and mix of all the sounds you can hear.

You will be asked to rate how the soundscape (all the sounds you can hear) makes you feel on a number of different scales. Circle on the scale the number which most closely represents how you feel based on the two words on either end of the scale.

You will be asked to do this 3 times a day. It should only take a couple of minutes each time.

Please look at the example and then turn over to complete the practice question.

Example

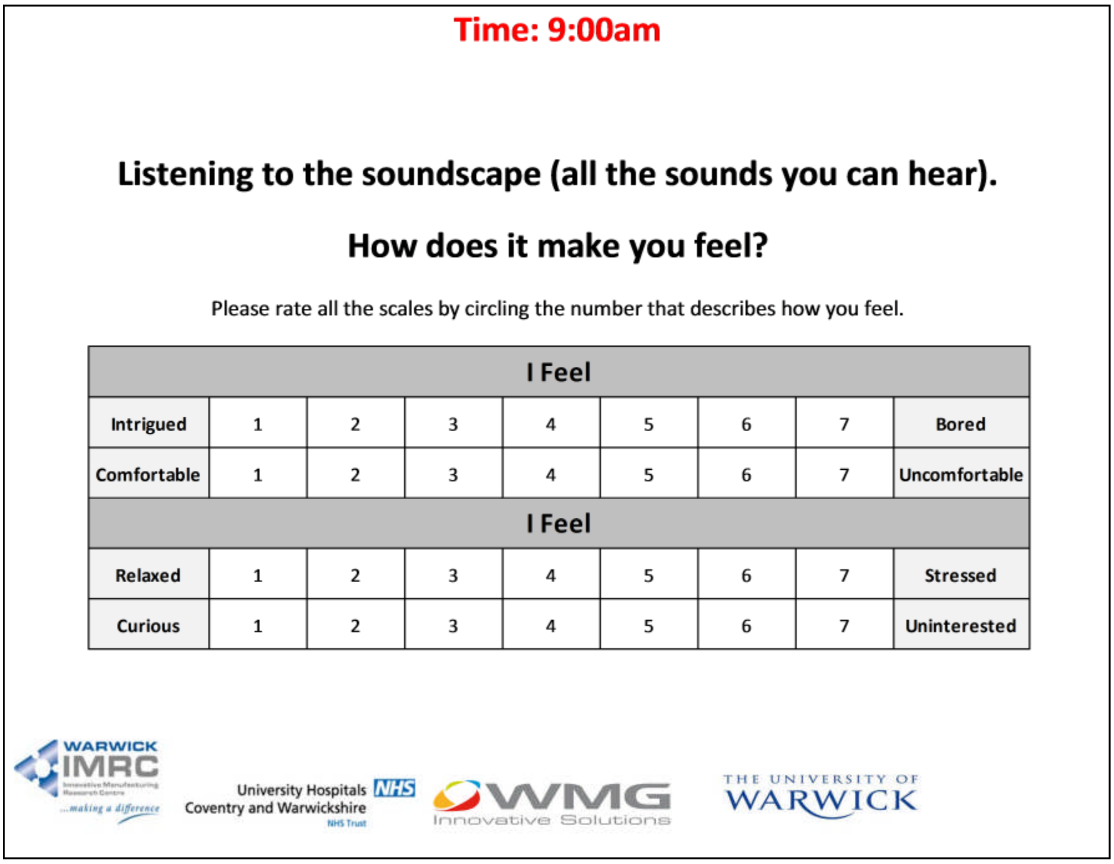
Listening to the soundscape (all the sounds you can hear).

How does it make you feel?

Please rate all the scales by circling the number that describes how you feel.

I Feel								
Intrigued	1	2	3	4	[✓ 5]	6	7	**Bored**
Comfortable	1	2	[✓ 3]	4	5	6	7	**Uncomfortable**
I Feel								
Relaxed	1	2	3	[✓ 4]	5	6	7	**Stressed**
Curious	[✓ 1]	2	3	4	5	6	7	**Uninterested**

If you have any questions please ask.



Time: 9:00am

Listening to the soundscape (all the sounds you can hear).

How does it make you feel?

Please rate all the scales by circling the number that describes how you feel.

I Feel								
Intrigued	1	2	3	4	5	6	7	**Bored**
Comfortable	1	2	3	4	5	6	7	**Uncomfortable**
I Feel								
Relaxed	1	2	3	4	5	6	7	**Stressed**
Curious	1	2	3	4	5	6	7	**Uninterested**

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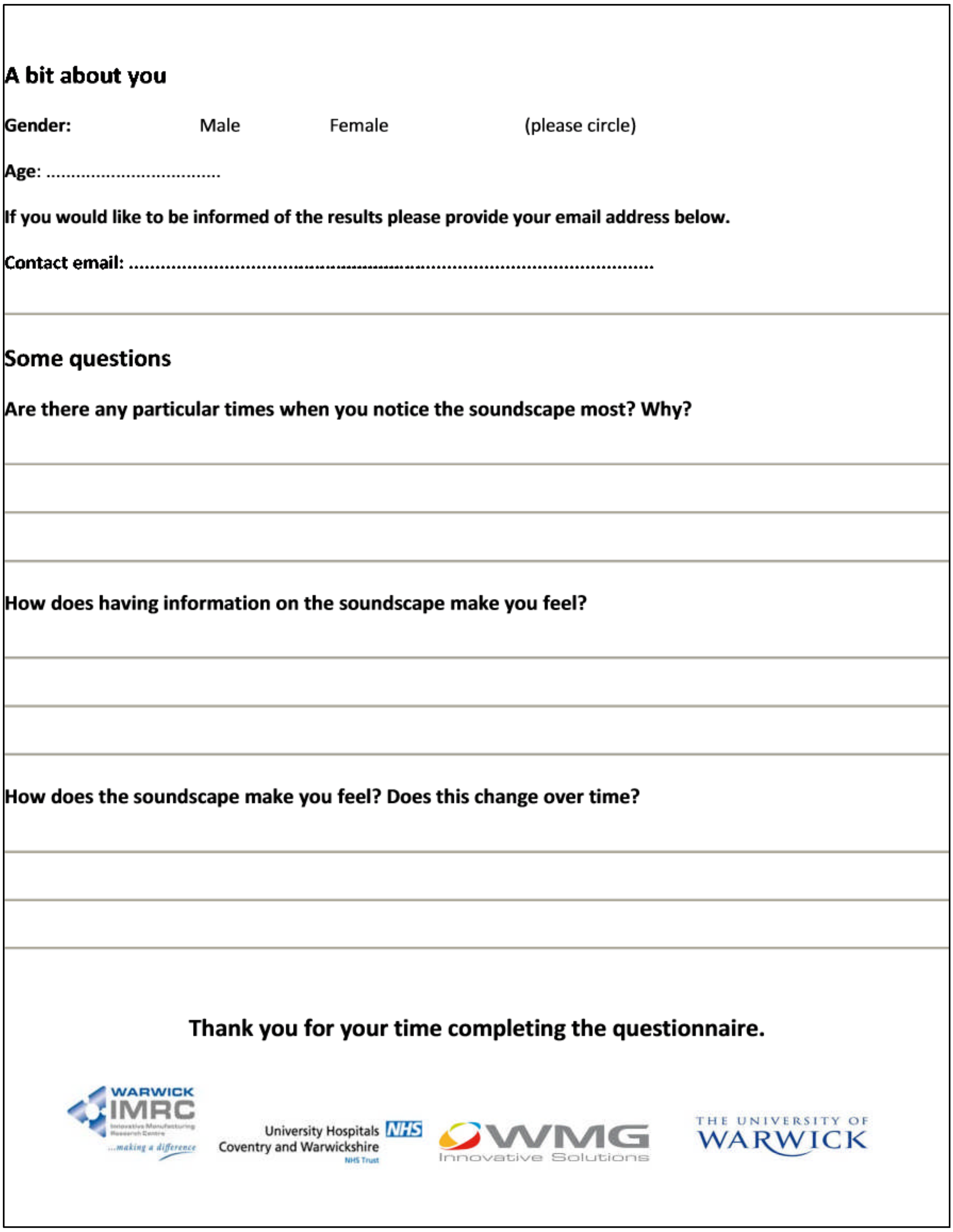


A bit about you

Gender: Male Female (please circle)

Age: ....

If you would like to be informed of the results please provide your email address below.

Contact email: ....

Some questions

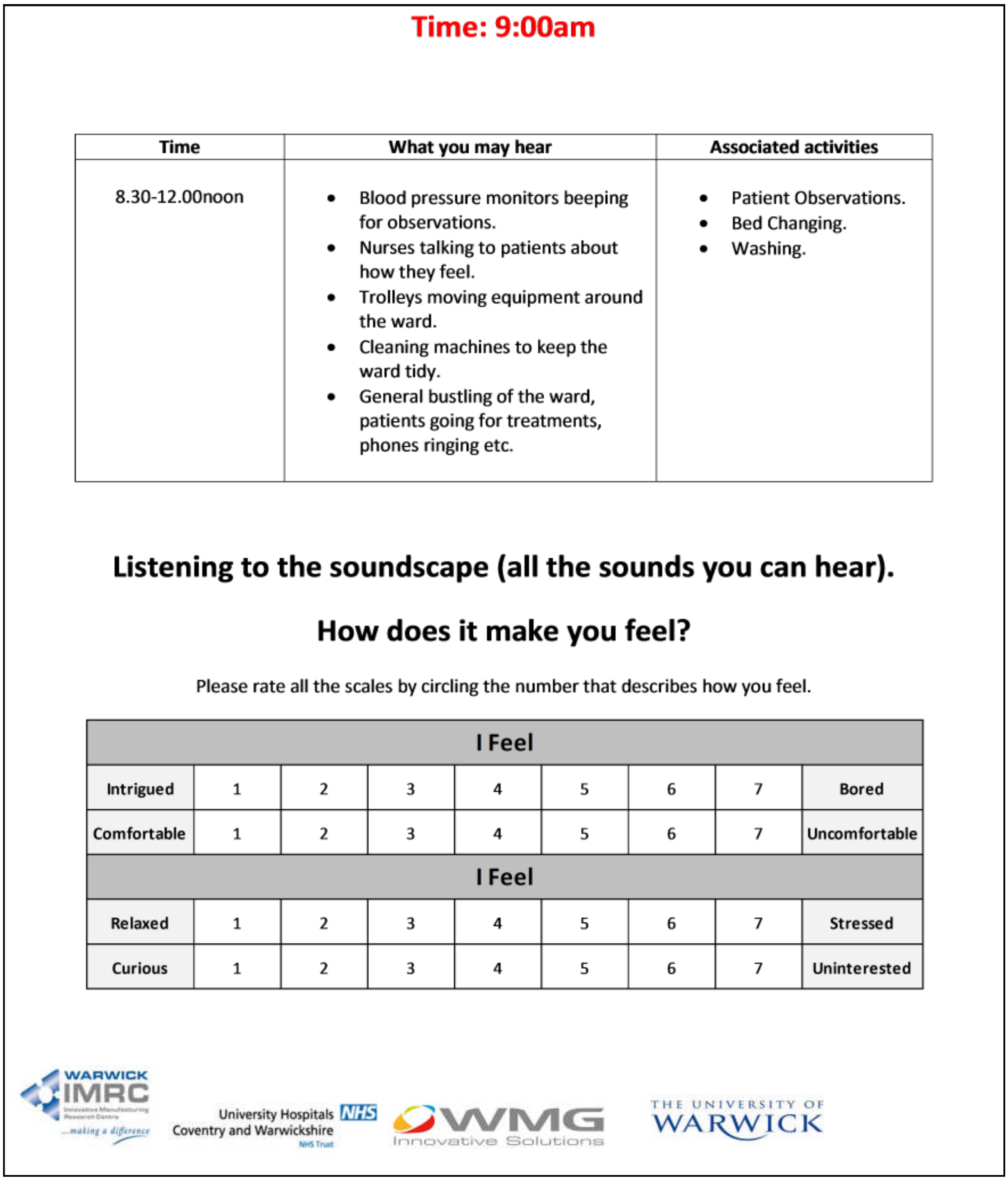
Are there any particular times when you notice the soundscape most? Why?

How does having information on the soundscape make you feel?

How does the soundscape make you feel? Does this change over time?

Thank you for your time completing the questionnaire.

5.2. Questionnaire B Sound source information intervention.



Time: 9:00am

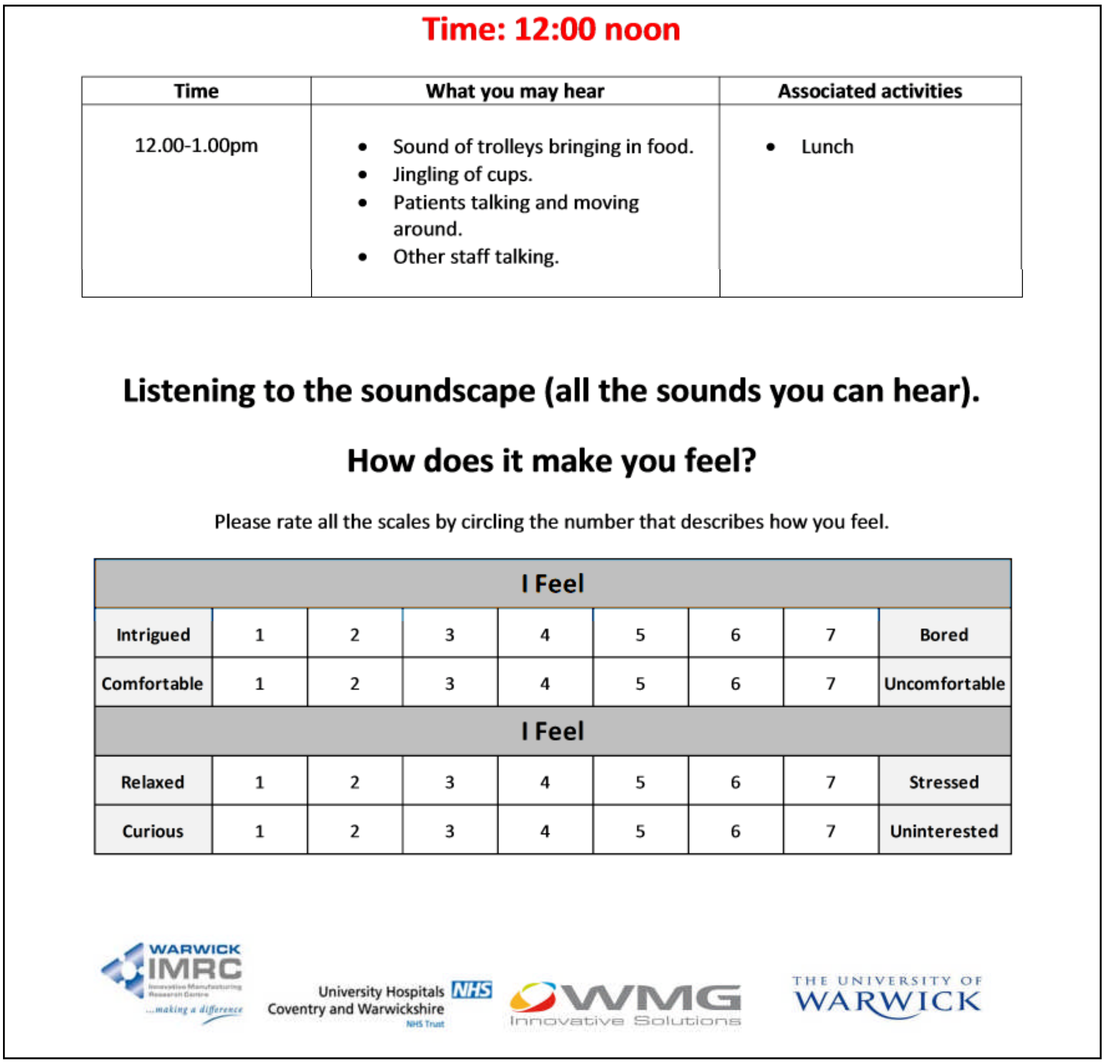
Time	What you may hear	Associated activities
8.30-12.00noon	• Blood pressure monitors beeping for observations. • Nurses talking to patients about how they feel. • Trolleys moving equipment around the ward. • Cleaning machines to keep the ward tidy. • General bustling of the ward, patients going for treatments, phones ringing etc.	• Patient Observations. • Bed Changing. • Washing.

Listening to the soundscape (all the sounds you can hear).

How does it make you feel?

Please rate all the scales by circling the number that describes how you feel.

I Feel								
Intrigued	1	2	3	4	5	6	7	**Bored**
Comfortable	1	2	3	4	5	6	7	**Uncomfortable**
I Feel								
Relaxed	1	2	3	4	5	6	7	**Stressed**
Curious	1	2	3	4	5	6	7	**Uninterested**



Time: 12:00 noon

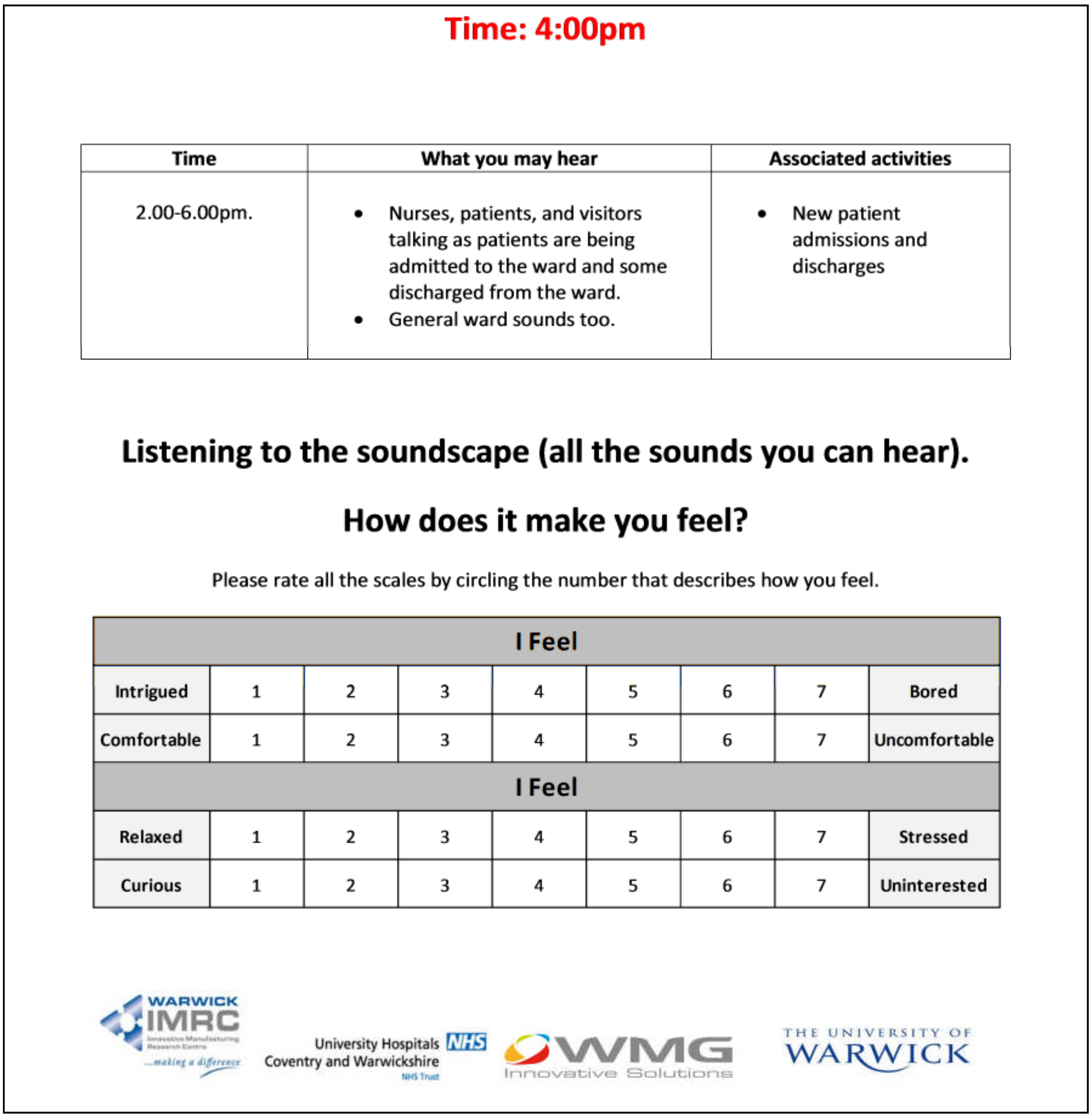
Time	What you may hear	Associated activities
12.00-1.00pm	• Sound of trolleys bringing in food. • Jingling of cups. • Patients talking and moving around. • Other staff talking.	• Lunch

Listening to the soundscape (all the sounds you can hear).

How does it make you feel?

Please rate all the scales by circling the number that describes how you feel.

I Feel								
Intrigued	1	2	3	4	5	6	7	**Bored**
Comfortable	1	2	3	4	5	6	7	**Uncomfortable**
I Feel								
Relaxed	1	2	3	4	5	6	7	**Stressed**
Curious	1	2	3	4	5	6	7	**Uninterested**



Time: 4:00pm

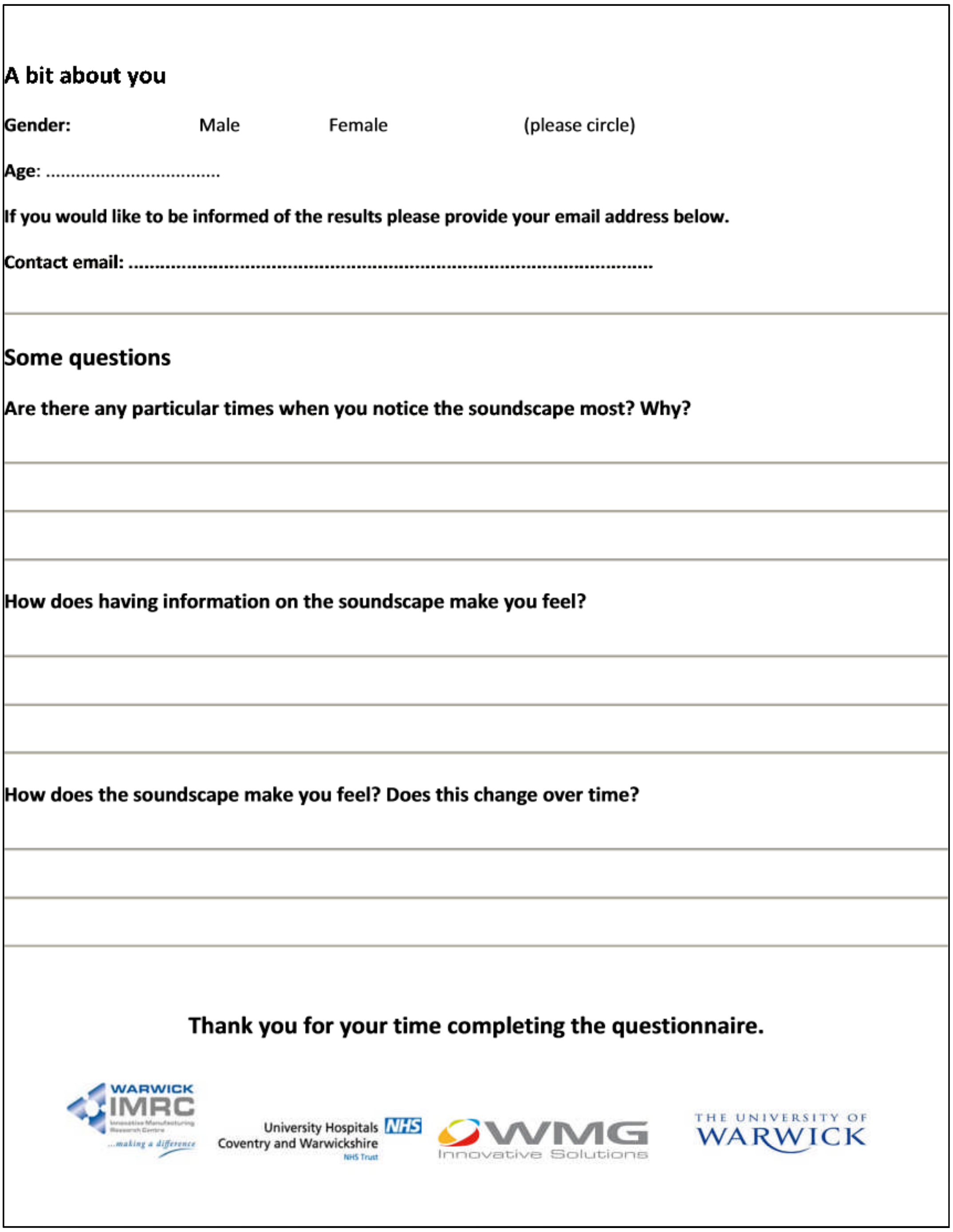
Time	What you may hear	Associated activities
2.00-6.00pm.	• Nurses, patients, and visitors talking as patients are being admitted to the ward and some discharged from the ward. • General ward sounds too.	• New patient admissions and discharges

Listening to the soundscape (all the sounds you can hear).

How does it make you feel?

Please rate all the scales by circling the number that describes how you feel.

I Feel								
Intrigued	1	2	3	4	5	6	7	**Bored**
Comfortable	1	2	3	4	5	6	7	**Uncomfortable**
I Feel								
Relaxed	1	2	3	4	5	6	7	**Stressed**
Curious	1	2	3	4	5	6	7	**Uninterested**



A bit about you

Gender: Male Female (please circle)

Age: ………………………………

If you would like to be informed of the results please provide your email address below.

Contact email: ………………………………………………………………………………………

Some questions

Are there any particular times when you notice the soundscape most? Why?

How does having information on the soundscape make you feel?

How does the soundscape make you feel? Does this change over time?

Thank you for your time completing the questionnaire.

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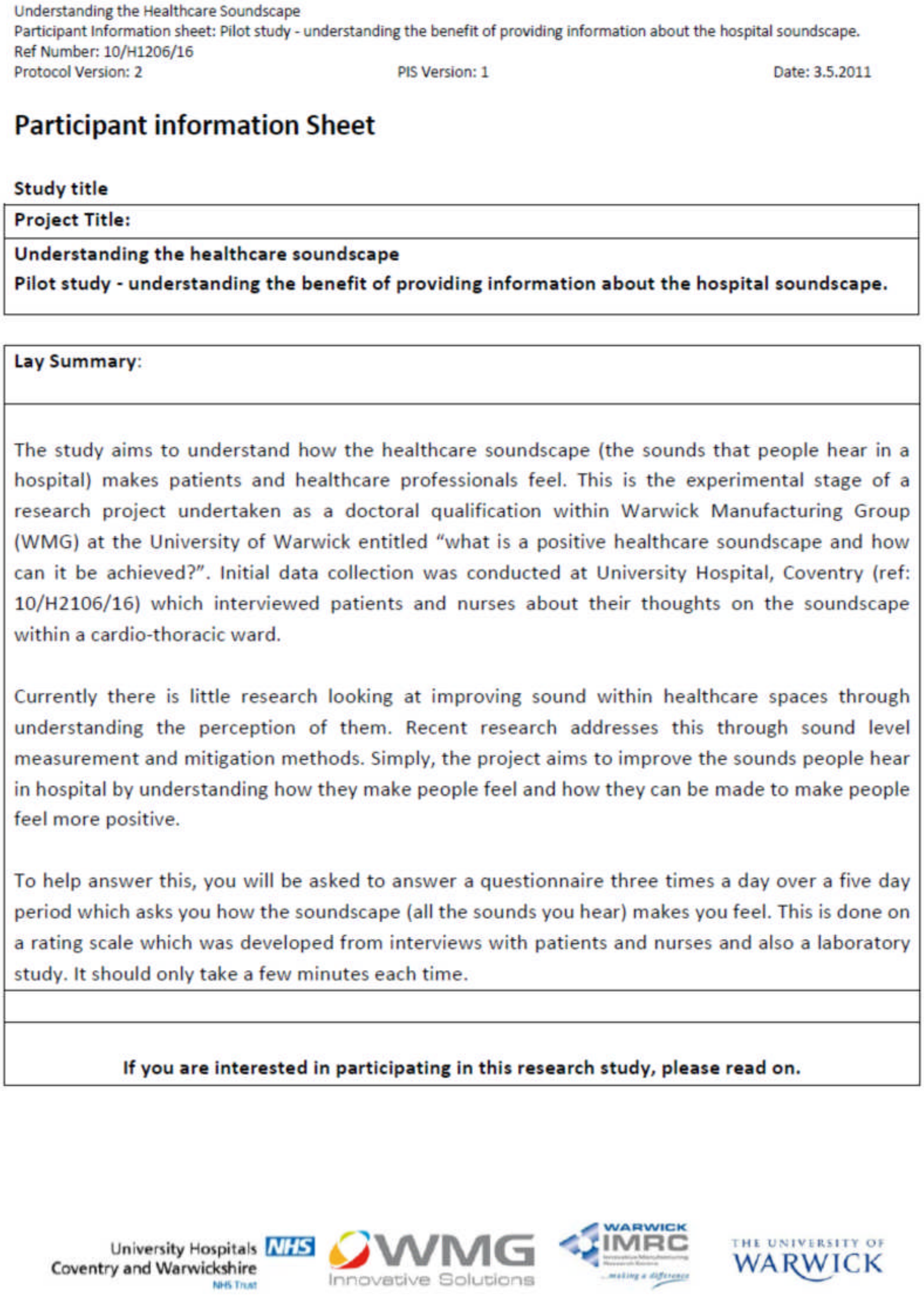
5.3. Participant information sheet and consent.



Understanding the Healthcare Soundscape
Participant Information sheet: Pilot study - understanding the benefit of providing information about the hospital soundscape.
Ref Number: 10/H1206/16
Protocol Version: 2 PIS Version: 1 Date: 3.5.2011

Participant information Sheet

Study title

Project Title:
Understanding the healthcare soundscape **Pilot study - understanding the benefit of providing information about the hospital soundscape.**

Lay Summary:

The study aims to understand how the healthcare soundscape (the sounds that people hear in a hospital) makes patients and healthcare professionals feel. This is the experimental stage of a research project undertaken as a doctoral qualification within Warwick Manufacturing Group (WMG) at the University of Warwick entitled “what is a positive healthcare soundscape and how can it be achieved?”. Initial data collection was conducted at University Hospital, Coventry (ref: 10/H2106/16) which interviewed patients and nurses about their thoughts on the soundscape within a cardio-thoracic ward.

Currently there is little research looking at improving sound within healthcare spaces through understanding the perception of them. Recent research addresses this through sound level measurement and mitigation methods. Simply, the project aims to improve the sounds people hear in hospital by understanding how they make people feel and how they can be made to make people feel more positive.

To help answer this, you will be asked to answer a questionnaire three times a day over a five day period which asks you how the soundscape (all the sounds you hear) makes you feel. This is done on a rating scale which was developed from interviews with patients and nurses and also a laboratory study. It should only take a few minutes each time.

If you are interested in participating in this research study, please read on.

Invitation

I would like to invite you to participate in my research study. Before you decide if you would like to participate I want you to understand why the research is being done and what it involves. This should take about 10 minutes to read to decide if you would like to participate or need more information.

What is the study about?

I am a doctoral student within WMG (Warwick Manufacturing Group) at the University of Warwick. The purpose of the study is to understand the perception of the hospital soundscape (all sounds you hear in a hospital). My research is looking at how the soundscape makes people feel and how it can be changed to make them feel more positive. To do this I am carrying questionnaire in which people rate how the sounds of the hospital make them feel.

Why have I been invited?

You have been invited as I want to understand patients response to the healthcare soundscape.

Do I have to take part?

Taking part is entirely voluntary and you should read the information sheet about what it involves. If you agree to take part you will be asked to sign a consent form agreeing to your participation in the study but you may withdraw at anytime.

What will happen to me if I take part?

You will be asked to fill in a questionnaire. This involves rating how the soundscape (all the sounds you can hear) make you feel. This is done on four scales which show how you might feel. You may or may not be given information on the soundscape to see if this information helps you. You will be asked to rate the soundscape three times a day (9am, 12 noon and 4pm) over four days. You will be asked to fill in a few short questions at the end.

Expenses and payments

There are no payments associated with being involved in the research.

What are the possible disadvantages and risks of taking part?

There are very little risks associated with the research and the main disadvantage is that it will mean that at the designated times you will have to complete the questionnaire..

What are the possible benefits of taking part?

The advantages are that you will be involved in research that will improve the understanding of the healthcare soundscape and that could potentially improve healthcare environments. It is also hoped that you find the experience interesting.

What if I want more information about the study?

If you have any questions about any aspect of the study or your participation in it please contact: James Mackrill, Professor Paul Jennings, or Dr Rebecca Cain.

Chief Investigator	**Academic Supervisors**	
James Mackrill	**Professor Paul Jennings**	**Dr Rebecca Cain**
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What if there is a problem and who should I contact if I wish to make a complaint?

If there is a problem with the research the University has in force a Public and Products Liability policy which provides cover for claims for "negligent harm" and the activities here are included within that coverage subject to the terms, conditions, and exceptions of the policy.

Any complaint about the way you have been dealt with during the study or any possible harm you might have suffered will be addressed. Please address your complaint to:

Patient Advice and Liaison Services

University Hospitals Coventry and Warwickshire NHS Trust
Ground Floor
University Hospital
Clifford Bridge Road
Coventry
West Midlands
U.K.
CV2 2DX

Email: PALS@uhcw.nhs.uk

Freephone: 0800 028 4203

Main office phone: 02476 966061

Will my taking part in the study be kept confidential?

Yes. All information which is collected about you during the course of the research will be kept strictly confidential, and any information will be kept within a locked filing cabinet in the office at the International Digital Laboratory. You will only be asked to provide basic information (age, gender) and you name will not be taken. You may provide contact details if you would like a copy of the results.

During the study data will be stored within a locked filing cabinet and on university owned computer which required a user name and password by James Mackrill at the office in the International Digital Laboratory. This data will be accessed only by James Mackrill and academic supervisors Professor Paul Jennings and Dr Rebecca Cain. After the study the data will be kept until the PhD has been completed and passed after which it will be destroyed.

It will not be possible to identify you from any published material arising from the study as anonymity will be ensured as all participants will be given a participant identification number.

What will happen if I don't want to carry on with the study?

If you do not wish to carry on with the study at anytime you can withdraw without reason. Any data you have provided will used in the analysis of the results unless you state otherwise.

What will happen to the results of the research study?

The results of the study will be written up and presented within academic papers and at conferences. The results will be used within the final PhD thesis. All data collected will be used for obtaining the results but no individual data will be specifically displayed, only the generic findings.

Who is organising and funding the research?

The PhD is funded by the Engineering and Physical Sciences Research Council (EPSRC) through the Warwick Innovative Manufacturing Research Centre (WIMRC) based within WMG (Warwick Manufacturing Group) at the University of Warwick.

Who has reviewed the study?

All research in the NHS is looked at by an independent group of people, called the Research Ethics Committee. This study has been reviewed and given a favorable opinion by Birmingham East North and Solihull Research Ethics Committee.

Understanding the healthcare soundscape
Consent form: Pilot study - understanding the benefit of providing information about the hospital soundscape.
REC number: 10/H1206/16
Protocol number: 2 Consent form Version: 1 Date: 3.5.2011
Centre Number:

Study Number:

Participant Identification:

CONSENT FORM

Title of Project: **Understanding the healthcare soundscape.**

Pilot study - Understanding the benefit of providing information about the hospital soundscape

Name of Researcher: **James Mackrill**

Please initial the box

1. I confirm that I have read and understand the information sheet dated 3.5.2011 (version 1) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected. ☐

3. I understand that I will be completing a questionnaire and James Mackrill and academic supervisors Professor Paul Jennings and Dr Rebecca Cain, will have access to this. I give permission for this. ☐

4. I agree to take part in the above study. ☐

Name of Participant: Date: Signature:

Name of Person (taking consent): Date: Signature:

James Mackrill

University Hospitals NHS
Coventry and Warwickshire
NHS Trust

WMG
Innovative Solutions

WARWICK IMRC
Innovative Manufacturing Research Centre
...making a difference

THE UNIVERSITY OF WARWICK

5.4. Tables showing descriptive statistics for results. *Note,* Skewness statistic <1.0 and z-score <1.96.

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean			Std. Deviation	Variance	Skewness		**Normalilty z-score (normaility = < 1.96**	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	**Mean statistic reversed for graph representation**	Std. Error	Statistic	Statistic	Statistic	Std. Error	**Skewness/SE skewness**	Statistic	Std. Error
Relaxation Control questionnaire at 9 time	43	5.00	1.00	6.00	3.3488	4.6512	.21016	1.37812	1.899	-.213	.361	-.589	-.598	.709
Relaxation Control questionnaire at 12 time	46	5.00	1.00	6.00	3.1739	4.8261	.16827	1.14123	1.302	.112	.350	.321	.507	.688
Relaxation Control questionnaire at 4 time	44	4.00	1.00	5.00	3.1136	4.8864	.16647	1.10424	1.219	-.777	.357	-2.173	-.479	.702
Relaxation Information questionnaire at 9 time	45	6.00	1.00	7.00	3.7111	4.2889	.27820	1.86623	3.483	.025	.354	.071	-1.043	.695
Relaxation Information questionnaire at 12 time	49	6.00	1.00	7.00	3.2653	4.7347	.24183	1.69282	2.866	.209	.340	.614	-.963	.668
Relaxation Information questionnaire at 4 time	44	6.00	1.00	7.00	3.4091	4.5909	.28029	1.85921	3.457	.389	.357	1.088	-.818	.702
Interest Control questionnaire at 9 time	43	5.00	1.00	6.00	3.3953	4.6047	.20819	1.36521	1.864	-.123	.361	-.339	-.615	.709
InterestControl questionnaire at 12 time	46	6.00	1.00	7.00	3.6087	4.3913	.19530	1.32461	1.755	.054	.350	.155	.129	.688
InterestControl questionnaire at 4 time	44	5.00	1.00	6.00	3.2727	4.7273	.17316	1.14858	1.319	-.182	.357	-.509	.079	.702
InterestInformation questionnaire at 9 time	46	6.00	1.00	7.00	4.3478	3.6522	.25484	1.72842	2.987	-.217	.350	-.620	-.955	.688
InterestInformation questionnaire at 12 time	50	6.00	1.00	7.00	4.3800	3.6200	.24393	1.72485	2.975	-.447	.337	-1.328	-.666	.662
InterestInformation questionnaire at 4 time	44	6.00	1.00	7.00	4.1591	3.8409	.24318	1.61307	2.602	-.340	.357	-.951	-.515	.702
Valid N (listwise)	24													