

**Audio-analgesia and Multi-disciplinary Pain  
Management: A Psychological Investigation  
into Acute, Post-operative Pain**

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# Abstract

**Background:** Audio-analgesia, the ability of music to reduce the perception of pain, has been a significant field of research in the past decade. This study aimed to investigate the impact of the musical constructs of harmonic and rhythmicity on acute, post-operative pain.

**Method:** 98 patients scheduled for primary total knee arthroplasty were randomly allocated at their pre-admissions clinic to one of four music listening groups, receiving commercially-available music. The participants in the experimental groupings were randomised according to the musical constructs of high/low harmonic and rhythmicity (four possible groups; ++, +-, -+, --). Music groups were compared against a silent control group, receiving quiet relaxation (with headphones). After surgery using a standardised anaesthetic regimen, all participants undertook a 15-minute listening/silent intervention on the ward for each day of their in-patient stay (max. 5 days). The primary endpoint was pain intensity. Salivary cortisol concentrations and mood stability were also monitored. Qualitative data was collected via daily feedback and assessed through thematic category analysis.

**Results:** A significant reduction in pain intensity from pre- to post-test was shown for all participants ( $p < 0.0005$ ), but with no difference between groups ( $F_{(4,68)} = 1.331$ , NS). Quiet relaxation (mean change: 22.27%) was as effective as music listening (mean change: 37.47%). Salivary cortisol concentrations showed an interaction between music with high harmonic and high rhythmicity (++) and music of low harmonic and rhythmicity (--). ++ music reduced cortisol concentration to a greater extent on Day 1 ( $p < .05$ ) than -- music. There was no significant difference between groups in mood disturbance. Qualitative data revealed four thematic categories of response: psychological, physiological, musicological and methodological, overall indicating that patients utilised their intervention as a distracting and relaxing cognitive-coping strategy.

**Conclusion:** Music is a viable therapeutic medium which reduced pain, as effectively as quiet relaxation. Compositional constructs were minimally active in the degree of analgesia and physiological changes experienced by patients, but where this did occur, it could be related to Berlyne's inverted-U model of musical preference (Berlyne, 1971). The positive reception of the interventions and the associated benefits, supports the inclusion of cognitive-coping strategies in multi-modal care pathways.

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Finally, thank you to my family and my husband Colin – your motivation, prayers and support have been invaluable.

# Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

*(Katherine Anne Finlay)*

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# Chapter 1

## Background

### 1.1 Personal Statement

This thesis represents a considerable personal challenge. It has been an invaluable experience, an opportunity to spend the duration of this PhD researching ‘pain’, a topic of real contemporary relevance and personal interest. Undertaking this thesis was an incredible opportunity to move beyond musicology and music psychology and to really engage with medicine, with health psychology and with practical, experimental, empirical research. When planning this PhD, there were two possible routes to take: firstly, to develop a deep knowledge of a small niche area of research, or secondly, to use this rare research opportunity to develop a wider knowledge-base under the guidance of a number of experts in medicine, psychology and music. It was this second route which was chosen and which this thesis represents. This PhD is not, therefore, a finite exposition of a well-defined niche of study—it is instead a wide-ranging overview of the many interactions between music and pain. Pain medicine is an enormous field with many avenues, down which it would be easy to venture. Therefore this PhD was begun with specific goals in mind: to learn how to conduct research within the National Health Service and to investigate acute, post-operative pain.

This thesis represents a clinical research study based in a busy NHS hospital. Completing this study involved negotiating the complexities of NHS ethics applications and learning the skills required to conduct research within a real-world medical context. This study necessitated work with a wide variety of clinicians from different fields and with different priorities. The patients recruited to the study were in a vulnerable post-operative setting, and were suffering from severe acute pain. This research led to a significant increase in knowledge of pharmacology, research design, pain profil-

ing and essentially of the wealth of skills needed to work with clinicians and patients on a daily basis. Pain is not just a physiological or psychological phenomenon, but a fusion of different domains of research. Thus this research looked not just at questionnaire data, but also at the physiological responses of patients to surgery and to the intervention. Much time was spent conducting physiological assessments and in the neuroendocrinology laboratory—sampling, assaying and analysing cortisol. Consequently, this has been an invaluable foray into medicine and into psychological and physiological research, learning some of the methodologies that are needed to assess the fullness of the pain experience.

This PhD is therefore representative of a broad interest in health psychology and, in particular, a personal interest in pain—how it affects people, what methods are used to test it and, importantly, what pain management techniques may modulate it. Allied with an academic background as a musician, the aim of the research was therefore to assess the use of music as a potential method of pain control with acute pain patients. This PhD has been a great opportunity and has facilitated a much deeper knowledge and experience of research which traverses the bounds of medicine, psychology and music.

## 1.2 Thesis Outline

Firstly, the fusion of the fields of medicine, psychology and music is outlined through an extended literature review. This begins with an overview of pain, osteoarthritis and cortisol literature, detailing what ‘pain’ is, pain theories and the background of and rationale for the pain assessment measures used in this thesis, the osteoarthritic patient population of the study in relation to the total knee arthroplasty, and finally the production and role of cortisol as a stress hormone. Chapters 3 and 4 deliberately look at the role of music in medical research. Chapter 3 refers to music and medicine literature through the individual dimensions of the Biopsychosocial Model of Pain (Engel, 1977). Looking firstly at the Biological dimension of the model, music research into pain and cortisol is outlined. The psychological dimension considers the literature surrounding cognitive-coping strategies, distraction and relaxation, musical preference, sense of personal control over clinical treatment and the emotional resonance of music. The sociological dimension refers to the potential of music to function as an ‘activity’ external to pain and as a potential method of pain control to be used in clinical practice. Chapter 4 is an important analysis of the literature surround-

ing methods of categorisation that have been used to select music for the purposes of medical research. This chapter considers possible constructs that could be used, in particular genre and compositional method. The chosen methods of categorisation for this study—Harmonicity and Rhythmicity—are defined and justified through previous research. The choices of musical extracts used in this study are listed, giving rationale for their inclusion. After the literature review outlined above, the methodology for the study is contained in Chapter 5, alongside the methodology for the cortisol collection and analysis in Chapter 6. Following this, the results of the clinical study are shown in Chapter 7, firstly through the primary outcome measures and then the secondary outcome measures. After the quantitative analysis, qualitative results are depicted using quotations from study participants. Finally, a few concluding paragraphs offer some thoughts for future research in the area of music and pain medicine.



# Chapter 2

## Pain, Osteoarthritis and Cortisol

### 2.1 Understanding Pain

Algology, the study of pain, defines pain as: “An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described of in terms of such damage” (IASP, 1994, p.1017). The breadth and depth of this description is significantly wider than might first be appreciated when considering ‘pain’. Traditional views of pain have prioritised the Cartesian concept of pain as a simple sensory stimulus-response model. Pain, according to this viewpoint, is a directly proportional response to the degree of bodily insult arising from a negative sensory stimulus. Yet pain is undoubtedly more complicated than this. Pain is dependent on internal (personal) and external (environmental) modulating forces and may be both positive and negative in affect. ‘Pain’ is not a universal experience which affects the entire populace similarly, but is a divisive and uniquely personal phenomenon. As stated by Melzack (1983), “Pain is whatever the experiencing person says it is, existing whenever he says it does” (p.71). It is this individual, varied, multi-dimensional, multi-modal concept of pain that is the challenge to all past, present and future research into pain management. It is with the aim of incorporating multi-modality into clinical care that the research in this thesis strives to contribute towards a greater understanding and insight into the potential of a music listening intervention to modulate pain.

Pain is traditionally categorised as a dyad, either acute or chronic in its longevity and condition (Melzack, 1973). Acute pain is classed as: “Pain of recent onset and probably limited duration. It usually has an identifiable temporal and causal relationship to injury or disease” (Ready and Edwards, 1992, p.2). Essentially, the acute pain sensation lessens over time (Stevenson, 1995) and acts as a protective mechanism, as a

warning response to provoke attention and force action in order to guard against further damage (Craig, 1999). Acute pain is evolutionarily effective for learning and injury limitation, prompting the organism towards activating pain avoidance strategies and the fight-or-flight response. Chronic pain, by contrast, is pain extending beyond three months and need not be tied to degree of tissue damage or to any biological function. Chronic pain may begin as an acute response to injury but this is not a requirement. It is often intractable and may have extreme negative physiological and psychological consequences (Wootton, 2002). Though pain is generally characterised as acute versus chronic pain, this in fact represents a continuum concept of the ‘pain experience’: the diagnosis may be either acute or chronic, but there exists fluidity between the two states. There is significant overlap depending on condition, diagnosis, treatment, the individuality of the person and their physiological and psychological response to pain.

Acute pain is, to some degree, predominant in modern, Western medicine. The process of diagnosing injury or illness, assessing the patient for the correct treatment methodology and then administering such treatment, perhaps through pharmacology or surgery, is a daily process for many clinicians and general practitioners. Such practice has proven highly effective for the majority of major and minor illnesses and for a large part of the patient population. Patients themselves are often seeking a ‘quick fix’; an accurate diagnosis, rapid treatment and a quick return to a healthy equilibrium. For these patients, acute pain is an accurate description of their pain experience—significant pain for a short period of time and little or no pain following successful treatment. It is clear from the outset that ‘pain’ is not a simplistic concept, but a rich opportunity for quantitative and qualitative work. This chapter will outline the predominant theories of pain in light of multi-modal research into pain, pain and psychology, attention and cognitive-coping strategies. It will then address research surrounding osteoarthritis and cortisol, in light of the aims of this thesis.

## **2.2 Theories of Pain**

### **2.2.1 Gate Control Theory**

The progression away from the Cartesian concept of pain where the degree of pain experienced was directly attributed to the extent of tissue damage, has been a gradual progression. The main proponents of pain research which pushed beyond such a uni-dimensional theoretical view of pain, have been Melzack and Wall (1965). Prior

to their research, there was no confidence in the hypothesis that pain signals could be modulated in any way, at any level. Pain was finitely considered a response mechanism and *not* a dynamical system. The change towards multi-modality followed the unveiling of Gate Control Theory. Gate Control Theory advocated that the spinal cord was an integral and operational mechanism for pain perception and signal modulation. Melzack and Wall (1965) proposed that the conscious apprehension of pain was modulated through a gate control mechanism in the dorsal horns of the spinal cord (Melzack and Wall, 1965). Gate Control Theory of pain has been adopted whole-heartedly by pain researchers and clinicians alike. Melzack and Wall changed the prevailing opinion by conceptualising the brain in terms of an active system that filters, selects and modulates informational inputs (Melzack, 1999).

Gate control theory states that pain impulses are transmitted from nociceptive receptors through the spinal cord to the Central Nervous System (CNS). As a pain signal passes through neural networks en route to or from the CNS, neural activity in the dorsal horns of the spinal cord acts as a 'gate'. The gate may be opened or closed at the dorsal horns and the transmission of pain impulses is either facilitated or inhibited at this level. The gate may therefore increase or decrease the number of pain impulses which pass from the nociceptive receptors to the CNS (see Chesky, 1992). If the pain impulse transmission is sufficiently inhibited by a 'closed gate' in the spinal cord, then the perception of pain in the CNS is blocked (Trout, 2004). Importantly, gate control theory stated that pain could result from or be modulated by psychological and sociological factors. No previous theory had incorporated these dimensions. Gate control theory states that there are cyclical interactions between pain and its causes, both internal (personal) and external (environmental). Thus it is inevitable that pain resonates on multiple levels and that there can be no direct correspondence between tissue damage and the amount of pain experienced. Pain is an individuated, multi-factorial experience influenced by culture, previous pain events, beliefs, mood and ability to cope. Due to the highly individual and subjective nature of pain, it is scarcely possible to experience pain without the specific contribution of personal psychological factors shaping the pain experience.

Work on gate control theory encompassed psychological components which were physiologically active in the process of pain signal modulation (see Melzack, 1983; Wall, 1999). Within the human body exists a basic level of natural chemicals—opioids such as endorphins or enkephalins (Fan, 2002). Opioids are considered generators of pleasant emotional mood states and contribute to pain relief (McCaffrey and Locsin,

2002). Stimulation of nerve impulses positively or negatively affects the levels of endogenous opioids within the body, modulating pain signal transmissions at the dorsal horns of the spinal cord (Fan, 2002). Mood state, in conjunction with resultant levels of opioids, therefore affects the on-going neural activity which precedes the stimulus (see Chesky, 1992). Similarly, following nociception, physical and psychological activity—for example, defensive movements, fear or unhappiness—also affect the impulses by promoting further neural activity (Melzack and Casey, 1968). Positive mood state in conjunction with opioids therefore can ‘close’ the gate and positively modulate signal transmission, whereas negative activity such as fear, movement or defensive action can prompt increased neural activity and heighten pain signals sent to the CNS by way of an ‘open’ gate. See Figure 2.1 for a diagrammatic representation of pain pathways.

### 2.2.2 Neuromatrix Theory of Pain

Gate Control Theory has been enormously influential in research, but there were some questions that its authors felt that it was unable to answer; principally those surrounding the issue of phantom limb pain. Phantom limb pain describes the pain experience of many amputees who, despite having had their limb amputated, continue to feel pain in that ‘phantom’ limb as if it were still present. Melzack (2001) felt that gate control theory failed to account for this phenomenon by which pain is perceived in the absence of sensory stimuli and also that it did not fully account for the perception of the body ‘as a unity’, not separate hierarchical levels of information processing. From these thoughts came four hypotheses which led to an extension of gate control theory. Melzack (1999) states that:

1. Phantom limb pain feels real, therefore all the qualities normally felt in the body are also felt in the absence of inputs from the body (i.e. pain).
2. The qualities felt may be represented as patterns in the neural networks of the brain. Stimuli may trigger patterns of neural response, but they do not ultimately produce them.
3. The body is perceived in unity as the ‘self’. The ‘self’ is distinct from others and the world and it is the point of orientation for understanding the surrounding environment. The sense of ‘self’ is produced by CNS processes and cannot be derived from the peripheral nervous system or the spinal cord.

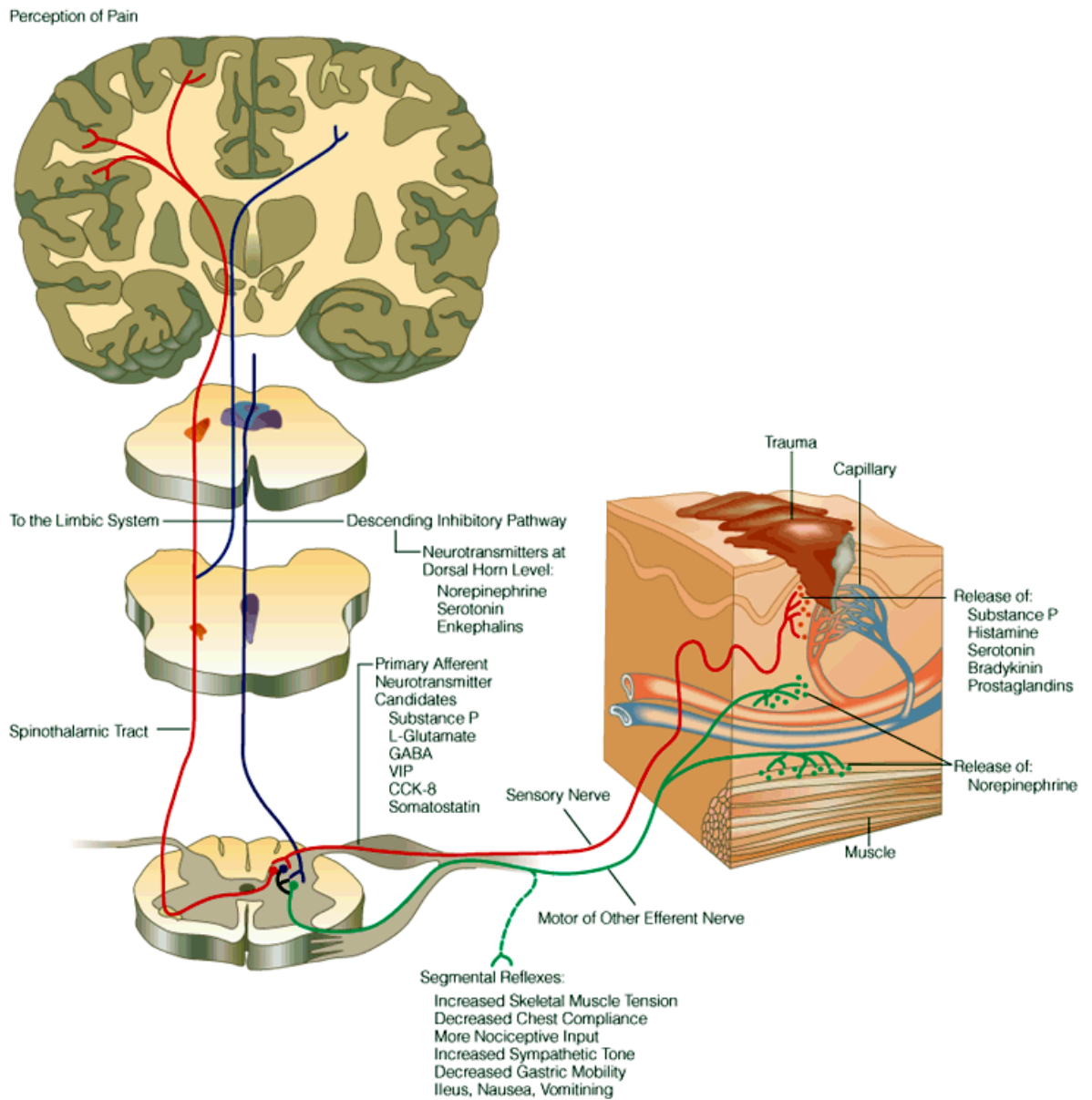


Figure 2.1: The mechanisms and pathways used to process a pain signal: possible methods of pain modulation (reproduced with permission from Walker (2007)).

4. The brain processes that underlie the 'self' are built-in by genetic specification but may be modified by experience.

The Neuromatrix Theory of Pain is the theory that has arisen from these observations. Advocated by Melzack (1999), it outlines the concept of a 'neuromatrix', a system of parallel and cyclical processing loops in the brain whose outputs converge to affect the ultimate perception of pain that is experienced by the conscious mind (Melzack, 1999). The neuromatrix is:

A network, whose spatial distribution and synaptic links are initially determined genetically and are later sculpted by sensory inputs... thalamo-cortical and limbic loops that comprise the neuromatrix diverge to permit parallel processing in different components of the neuromatrix and converge to permit interactions between the output products of processing (Melzack, 1999).

To clarify, the neuromatrix is a genetically constructed matrix of neurons via which the whole body functions—a synaptic architecture. These neurons produce characteristically synthesised and cyclical nerve impulse patterns for the body. These are uniquely personal and may be termed a 'neurosignature'. The neurosignature is formed through patterns of nerve impulses of varying temporal and spatial dimensions produced by the neural programs of the neuromatrix (Melzack, 2001). Neuromatrix theory is tied to gate control theory by way of the dorsal horns in the spinal cord which transmit and modulate signals. Signals are thought to originate from three parallel processing networks, alongside the autonomic nervous system, stress response system and immune system (Trout, 2004). The parallel processing networks are:

1. **Sensory-Discriminative Network**

Somatosensory system: ascending neurons in the spinothalamic tract, the thalamus and the primary somatosensory cortex (Craig, 1999). It maps the nature of the stimulus (thermal, mechanical or chemical) and the bodily location, intensity and temporal aspects of the pain (Craig, 1999).

2. **Affective-Motivational Network**

Limbic system: diencephalic and telencephalic structures, the medial thalamus, hypothalamus, amygdala and limbic cortex (Craig, 1999). Controls issues surrounding the emotions of concern and the arousing, compelling and directing nature of these emotions as they evoke action in the form of reflexes, emotions or complex behaviour concerned with escape and avoidance (Craig, 1999).

### 3. Cognitive-Evaluative Network

Thalamocortical systems: the thalamus, thalamocortical fibres, thalamic reticular nucleus, and signals that pass through the thalamus en route to the cortex via the optic tract (vision), inferior colliculus (audition) and medial lemniscus (somatosensation). This enables psychological processing of pain/information signals and the evaluation of these in relation to maintaining the homeostasis of the organism.

These three processing networks (the neuromatrix) are thought to converge in a patterned 'neurosignature' which specifies individual pain perception and voluntary and involuntary 'action systems' in which a person takes action in response to their pain via personal pain coping strategies (Melzack, 2001; Trout, 2004). The neuromatrix may be genetically pre-determined, but it is still malleable (plastic) through repetitive neural patterning, priming and in response to psychological and sociological endogenous and exogenous events.

### 2.2.3 Biopsychosocial Model of Pain

The relationship between biology, psychology and sociology may be represented generically through the Biopsychosocial model of pain. Engel (1977) advocated the Biopsychosocial model as a formalisation of multiple dimensions active in the pain experience, each with the potential to modulate and influence pain. The Biopsychosocial model was an early theoretical precursor to the Neuromatrix and Gate Control Theories of pain (see Melzack and Wall, 1965; Melzack, 2001) and it remains one of the most effective pictorial representations of pain. In the Biopsychosocial model (see Figure 2.2), pain is not simply the consequence of biological influences, but is equally the result of psychological and sociological factors. Biologically, factors such as diagnosis and treatment are important, alongside anatomy and physiology through pain pathways, pain neurology and the Neuromatrix. Psychologically, personal expectations may impact upon response to treatment, as may emotional issues such as anxiety, depression, anger and personality. The psychological dimension of pain has been outlined by Melzack and Casey (1968) as a synergy of the three themes: sensory-discriminative, affective-motivational and cognitive-evaluative. Each of these themes contribute to the person's response to pain, in combination with their memories of earlier pain events which generate meaning and assist in the evaluation of the pain experience. It is also

thought that these themes are replicated physiologically by specialised systems in the brain (see page 9). In this way the Biopsychosocial model innately justifies and provides a solid grounding for the gate control and neuromatrix theories of pain. The final dimension of the Biopsychosocial model is sociology. Sociologically, culture and family context often dictate the way in which people respond to pain and the support structures available may impact upon work avoidance and social functioning for example. The three dimensions, biological, psychological and sociological represent an endless list of possible themes which interact, overlap and together ultimately form and influence the fullness of the ‘pain experience’.

Though the Biopsychosocial model of pain may represent a ‘gold standard’ for working with pain sufferers, the reality is easily very different. To work with patients across all three dimensions of the Biopsychosocial model is an expensive, time-consuming and often impossible dream. In light of the ever-increasing demands on clinicians’ time, hospital finances and with capped maximum waiting times for hospital waiting lists, the available resources for implementing and monitoring a fully Biopsychosocial program of care are limited. The alternative to a biopsychosocial model is a dependence upon a biomedical model—essentially a bio-bio-bio approach.

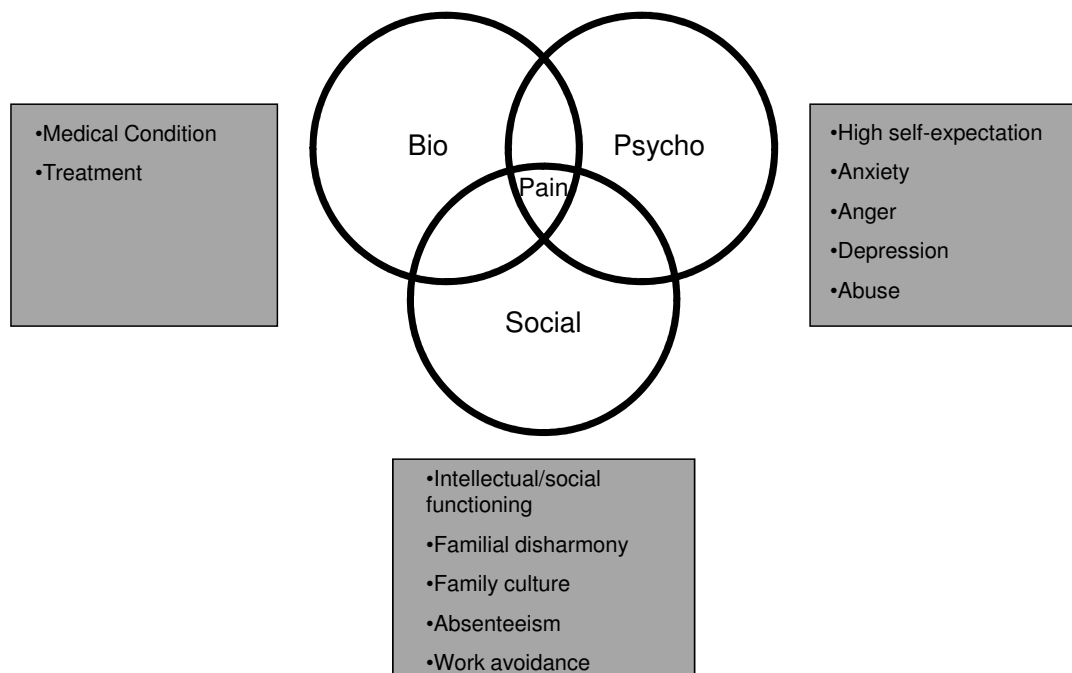


Figure 2.2: A pictorial representation of the Biopsychosocial Model of Pain (following Engel, 1977)



Concern about a potential chasm between standard biomedical care and the desire for Biopsychosocial approaches led the American Psychiatric Association to comment that:

There is widespread concern at the over-medicalization of mental disorders and the overuse of medications. Financial incentives and managed care have contributed to the notion of a 'quick fix' by taking a pill and reducing the emphasis on psychotherapy and psychosocial treatments . . . This is true despite the strong evidence base that many psychotherapies are effective used alone or in combination with medication . . . If we are seen as mere pill-pushers and employees of the pharmaceutical industry, our credibility as a profession is compromised (Sharfstein, 2005, p.3).

It is not just in mental health that this concern has arisen; general medicine is also at risk of prioritising the 'bio' and neglecting the 'psycho' and 'social'. There is a wealth of evidence to suggest that although a bio-bio-bio approach can be successful, the benefits of multi-modal approaches to health are significant (for examples see Aldrich and Eccleston, 2000; Herman et al., 2005; Lavernia et al., 1997; Turk and Okifuji, 1999; Turk et al., 2006). Following surgery, standard biomedical care does improve the ability of the patient to cope physically and psychologically and their functional capacity is increased (Nimmo, 2006). However, the use of multi-modal strategies post-surgery improve functional capacity even further and also reduce the amount of time spent in recovery and therefore the time spent as a post-operative in-patient. Multi-modal care is therefore be advantageous for patients, for clinicians in their drive for improvements in patient health-status, and also NHS Trust (or similar) where maintaining integrated multi-modal care could have positive financial implications.

Through Gate Control Theory, Neuromatrix Theory and the Biopsychosocial model of pain, it is possible to understand pain as a multi-dimensional phenomenon. With the advent of these theories, it is no longer appropriate to neglect psychological and sociological factors. Gate Control and Neuromatrix theory have justified multi-modality theoretically and neurologically in relation to pain processing. The Biopsychosocial model provides an easily explicable representation of pain which could impact medical care to a greater degree. Pain theory is therefore integrational and clinical practice should strive towards the practical outworking of this in the context of daily patient care.

## 2.3 Pain and Psychology

### 2.3.1 The Role of Attention

Bio-bio-bio or biomedical models of pain prioritise the sensory components of the pain experience. Yet pain also has the power to disrupt behaviour and thought (Melzack and Casey, 1968; Melzack and Torgerson, 1971). Questions then arise surrounding how psychology interacts with pain, and in particular what is the role of psychological theory and methodology in explaining and theorising pain modulation? The key to comprehending the modulatory relationship between pain and psychology is an understanding of attention. Pain is demanding of attention. Pain signals interrupt and interfere with daily activity (Gillanders, 2006) and the processing of pain signals is prioritised by the Central Nervous System (Eccleston and Crombez, 1999). Consequently, pain has the potential to become a focus of attention, at the disadvantage of other activities which also require attention.

This prioritisation of pain-signals is theorised through the traditional model of attentional capacity. Baddeley (1986) posited that attention is finite in capacity and is allocated appropriately and divided between tasks. Attention is seen as a limited resource which is given to the processing of attended-to information at the expense of less important tasks or activities of low priority. In particular, multiple tasks can be difficult to perform simultaneously (Eccleston and Crombez, 1999). The appropriate distribution of attentional resources and effective completion of tasks can become flawed when the combined activity required by the tasks exceeds the limits of the available attentional resources. The processing of information is divided two-directionally: 'bottom-up' and 'top-down' processing. Automatic, bottom-up processing is unconscious and occurs without invoking attention and is driven by attributes of the stimulus itself. Effortful, top-down processing requires deliberate goal-oriented control of attention and cognitive capacity as the subject drives information processing through deliberate strategies and intentions (Hammar et al., 2003). Any given task ordinarily requires a combination of these two methods of information processing (Eccleston, 1995).

Essentially:

The primary purpose of an attentional system must be to ensure the coherence of behaviour under often conflicting constraints. Coherent, goal-directed behaviour requires processes of selective priority assignment and co-ordination at many different levels (motivational, cognitive, motor, sensory). Together this set of selective and co-ordinative processes can be said

to make up the effective attentional engagement (or attentional set) of an organism at any moment (Allport, 1989, p.652).

Just as pain is viewed as a challenge to attentional resources: attentional resources can constitute a challenge to pain. The relationship between pain and attention is mutually influential. Pain is interruptive, it distracts from normal activity and demands the focus of the pain sufferer. Pain signals force attention to be directed towards them in order to motivate avoidance behaviour which may reduce or remove the noxious stimulus (Eccleston and Crombez, 1999). Pain signals impose a new action priority on the organism to escape. Due to the limited availability of attentional resources, the attentional system becomes selective in processing and filtering information when in a situation of heightened attentional demand, such as that of a complex task or in response to pain (Eccleston, 1994). A painful stimulus elicits an attentional shift, as attention is redirected from a task to attend to the pain signal and pain context. Conversely, if attention is absorbed by other demands (such as complex tasks), then there are fewer attentional resources available to attend to pain. If a task is appropriately demanding, requiring a significant amount of attentional resources, then the attentional resource-base may be depleted. Though pain signals are evocative of the finite attentional resources and are effective at interrupting activity, if attention is persistently directed elsewhere, the ability to attend fully to pain is inhibited. Ultimately, attention engaged in non-pain demands cannot be allocated to pain processing (McCaul and Malott, 1984). Selective attention alerts the prefrontal cortex to the distractor rather than to the noxious stimulus and thereby inhibits pain (Good et al., 2005). It is in response to this theoretical perspective that attention-based approaches to multi-modal pain management have arisen.

### **2.3.2 Cognitive-coping Strategies**

A central tenet of multi-modal pain management is that of cognitive-coping strategies. By encouraging the patient to engage actively in redirecting their attention away from the pain stimulus, pain intensity may be reduced and pain tolerance increased. Research surrounding the efficacy of cognitive-coping strategies has not yet reached a consensus on the applicability of these approaches, but they have been formalised (alongside other methods) in cognitive-behavioural therapy (CBT). Cognitive-behavioural therapy addresses habitual actions, and is designed to enable patients to recognise and deal with maladaptive and habitual patterns in pain responding through the reprogram-

ming and reorienting of thoughts (Turk and Okifuji, 1999). This re-conceptualisation is facilitated by addressing the impact of thoughts, habits, fears and self-beliefs on pain levels. Cognitive-behavioural therapy is designed to encourage the patient to exert more control over their treatment and to understand the role of cognitive factors in exacerbating pain and suffering. It is essentially a psychological method of promoting physical (and psychological) pain management and is an effective and clinically relevant treatment.

In order to return the locus of control to the patient, cognitive-behavioural therapy teaches patients to work towards reducing and coping with their pain more effectively through learned techniques (Chesky, 1992). A principal methodology surrounds cognitive-coping strategies. Six categories of cognitive-coping strategies have been identified (Fernandez and Turk, 1989): pleasant imaginings, rhythmic cognitive activity, external focus of attention, pain acknowledging, dramatised coping and neutral imaginings. These may be categorised as: (1) imagery, (2) self-statements and (3) attention-diversion techniques. Fernandez and Turk (1989) analysed the literature in each of these areas and concluded that strategies which increase the locus of control or which relocate attention, distracting from pain, are the most effective. Leventhal (1992) pushed this hypothesis further by suggesting that due to the affective nature of pain, cognitive-coping strategies with an emotional content might work most effectively. It is in this context that music may be most valuable. Music facilitates imagery, is a statement of the self through musical preference or personal identification with a fan-base and is an attention-diversion strategy. Chapter 3 outlines this further.

Distraction of attention is a commonly used coping strategy to control pain in everyday situations (Van Damme et al., 2008). Distraction is also regularly used in cognitive-behavioural therapy. By distracting and diverting attention from the pain experience, patients are encouraged to engage in tasks and activities external to their pain. Research into distraction has shown that distraction can facilitate pain reduction (see for example Boyle et al., 2008; Eccleston, 1995; Eccleston et al., 2002) and increase pain tolerance (Van Damme et al., 2008). Distraction methods researched to date have included humour (Mitchell et al., 2006), arithmetic (Mitchell et al., 2006), relaxation tapes (Good et al., 1999, 2004), relaxation instructions (Hirokawa, 2004), white noise (Boyle et al., 2008), guided imagery (Janata, 2004), music therapy (Lee et al., 2005a; Maratos and Gold, 2005; Wigram et al., 1995), music and therapeutic suggestions (Nilsson et al., 2001, 2003), experimenter-chosen music listening (Good, 1996; McCaffrey and Locsin, 2002; McCaffrey and Freeman, 2003) participant-directed pre-

ferred music listening (MacDonald et al., 2003; Mitchell et al., 2006) and quasi-preferred music listening (Good et al., 2000, 2004, 2005).<sup>1</sup>

The results of these studies have been highly variable. Though many have shown positive benefits, some have not (MacDonald et al., 2003, for example) and this contradiction was detailed in the recent Cochrane Library Review by Staricoff (2004). Though research progress in the field of distraction and pain has been widespread and experimental, comparability between research projects has proven extremely difficult. A lack of standardisation or cohesion in the distraction induction procedures tested, the patient populations evaluated, the difference between laboratory-induced pain and actual (clinical) pain and ultimately the measures used for assessment, means that as yet it is still not possible to finitely conclude whether distraction is a viable, effective and consistently beneficial methodology. As Leventhal (1992) stated, there is a general consensus that distraction is effective, but the literature to date has not fully validated this supposition. Future research needs to take care to differentiate between distraction induction procedures, to outline clearly the study methodology and to work towards an understanding of the difference between laboratory-induced pain and actual acute or chronic pain. In addition, such distraction research needs to work in tandem with mainstream pain trials which are actively promoting the standardisation of analysis measures and methods. Work by the Initiative on Methods, Measurement and pain Assessment in Clinical Trials (IMMPACT) group has provided clear and helpful guidelines in this regard (see Dworkin et al., 2005, 2008; Kerns, 2005; Turk et al., 2006). Consequently, the research contained in this thesis has attempted to maintain transparency in methodology and the interventions used.

## 2.4 Arthritis

The patient population assessed in this thesis was that of arthritic knee pain sufferers, hence this section details the incidence of arthritis and the treatment and surgery undertaken by these patients. Total joint replacements are most often proposed for patients who suffer from severe ‘arthritic change’ within their joints. Therefore for the purposes of this study, knee arthritis will be addressed specifically, with an emphasis on osteoarthritis, the largest causative factor identified in this research.<sup>2</sup> The incidence

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<sup>1</sup>Quasi-preferred music refers to music chosen by the participant from within a predetermined, experimenter-prepared selection of possible options. See page 40 for more detail.

<sup>2</sup>This is in line with a recent review of the literature, in which Ethgen et al. (2004) found that the majority diagnosis for 74 published total hip and knee arthroplasty studies was osteoarthritis.

of knee arthritis is above that of hip arthritis, and approximately 1 in 50 people over the age of 55 years would likely benefit from knee replacement surgery (Moran and Horton, 2000). Osteoarthritis in the knee is a debilitating condition affecting over 6% of the adult population; a statistic that rises with age (Felson et al., 1987). Osteoarthritis is a common disorder of synovial joints (Dieppe and Lohmander, 2005) and affects all structures within these joints (Felson, 2006).

### 2.4.1 Diagnosis and Treatment of Osteoarthritis

Treatment for arthritis is best staged through the pyramidal approach advocated by Dieppe and Lohmander (2005):

- **Level 1**

At the base level, treatments concern patient (re-)education. Patients often fear activity when they experience pain on movement as a result of their osteoarthritis, but in fact this can contribute to a worsening of functional ability. Lack of movement results in loss of muscle tone, stiffness and ultimately, loss of independence. Exercise and weight loss in order to improve function and reduce forces upon the knee, have been advocated by Roddy and Doherty (2006).

- **Level 2**

Self-help methodologies are based at the second level. Self-help consists of elements such as the self-administering of analgesia through paracetamol, ibuprofen or anti-inflammatory topical gels, and also vitamin-based supplements such as glucosamine and chondroitin.<sup>3</sup> Lifestyle is also implicated in treatment at this level, as patients may improve their symptoms through a reduction in smoking, monitoring dietary intake and via occupation changes. It is suggested that occupations which require heavy lifting and significant bending may precipitate early onset of osteoarthritic disease and more rapid symptomatic degeneration (Dieppe and Lohmander, 2005).

- **Level 3**

At the third level are non-steroidal anti-inflammatory drugs (NSAIDs), which

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<sup>3</sup>The efficacy of glucosamine and chondroitin are not proven, despite widescale usage. Recent studies have shown no greater benefits than placebo (Clegg et al., 2006). Exploratory analyses suggested that there may be an exception to this, with some benefits shown in a subgroup of patients with moderate-severe osteoarthritic pain when both glucosamine and chondroitin are taken in combination. Further research should investigate this exploratory finding.

have been found to be more effective than placebo (Felson, 2006). Also, professional intervention and advice, such as that provided by physiotherapists or occupational therapists. Physiotherapy can reduce quadriceps wastage, benefiting patients with osteoarthritis of the knee (Kidd, 2006). Occupational therapists can provide insoles to help rectify postural malalignments and other assistive-equipment such as walking aids may be recommended for use.

- **Level 4**

Treatment at the penultimate level includes steroidal injections to reduce inflammation and provide pain relief. It also encompasses minimally-invasive arthroscopic surgery in which keyhole surgery is used to debride torn, loose cartilage and to remove foreign bodies from within the joint capsule.

- **Level 5**

At the top and final level is the treatment assessed through this research study: surgical interventions. Surgical interventions may be total (as in this study), partial, resurfacing-based and osteotomies (principally for hip dysplasia). Only a small proportion of the vast number of osteoarthritis sufferers in the general populace ultimately require joint replacement surgery (Dieppe and Lohmander, 2005).

After a patient has been diagnosed with osteoarthritis and has been treated according to the pyramidal therapy structure with limited or no success (see Figure 2.3 for explanation), patients may be referred for a 'Level 5' surgical intervention. Total knee arthroplasty is in essence the optimal management procedure for patients suffering from end-stage joint deterioration as a result of their osteoarthritis or rheumatoid arthritis (Ethgen et al., 2004; Lingard et al., 2004). To clarify, total knee arthroplasty is indicated for:

Patients with intractable pain and substantial functional disabilities who have not had acceptable relief and functional improvement after conservative treatment and who are not candidates for other non-ablative reconstructive procedures such as arthroscopy (Kroll et al., 1989, p.963).

## **2.4.2 Total Knee Arthroplasty**

A knee replacement operation involves replacing the damaged and worn sections of the knee with prosthetic parts which model the anatomy and mobility of the normal

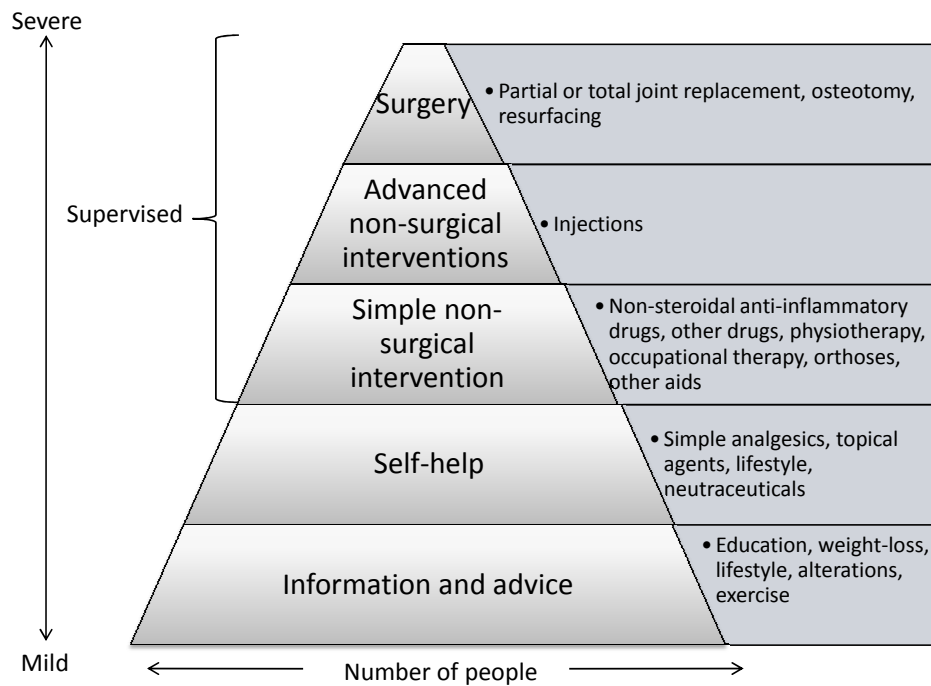


Figure 2.3: Principles of the management of osteoarthritis: suggested sequential, pyramidal approach to disease management (taken from Dieppe and Lohmander, 2005).

knee. The prosthetic parts reduce the pain experienced by the patient by improving knee function, removing damaged bone and tissue and realigning the knee joint. The knee joint is primarily constructed of the end of the femur (see Figure 2.4) and the tibia. The ends of these two bony surfaces are protected by a covering of articular cartilage which absorbs shock and allows the bones to glide past each other (BUPA, 2008). Long-term wear and tear often causes damage to the articular cartilage and ultimately challenges the integrity of the bony surfaces themselves. A total knee arthroplasty removes the worn cartilage and the ends of the femur and tibia and replaces these with a free-moving prosthesis. The surgery generally lasts approximately two hours and is conducted under epidural with sedation and nerve blocks (see page 116 for description of analgesic agents used in this research). The surgeon makes an incision in the front of the knee of approximately 20–25cm in length. The patella (kneecap) is moved to one side in order to access the joint and the worn surfaces are removed from the femur and tibia (Witt, 2008). The size of the knee is assessed using prosthetic templates and the bony surfaces are shaped correctly to fit the prosthesis. The prosthesis is then



cemented in place over the ends of both bones and the patella is returned to its normal location. The wound is closed using sterilised metal clips and is dressed appropriately. Following surgery the patient is generally resident for in-patient care for approximately 3–5 days post-operatively.

### 2.4.3 Osteoarthritis and Pain

Controlling post-operative pain is one of the largest issues surrounding surgical interventions. Over 25% of people over the age of 55 years have experienced knee pain on most days in a month in the past year (Felson, 2006). Such levels of chronic osteoarthritic pain are thought to be present in 10–15% of the United Kingdom population at any one time (Elliott et al., 1999). Half of these cases demonstrate symptomatic, radiographic osteoarthritis and many have osteoarthritis which is not identifiable by x-ray (Felson, 2006). It is thought that greater than one in five people suffer from persistent back or joint musculoskeletal pain (Kidd, 2006). Pain and stiffness are fundamental roots of patient dissatisfaction after undergoing total knee arthroplasty (Fisher et al., 2007), thus they need to be addressed as a priority. Orthopaedic surgeries are thought

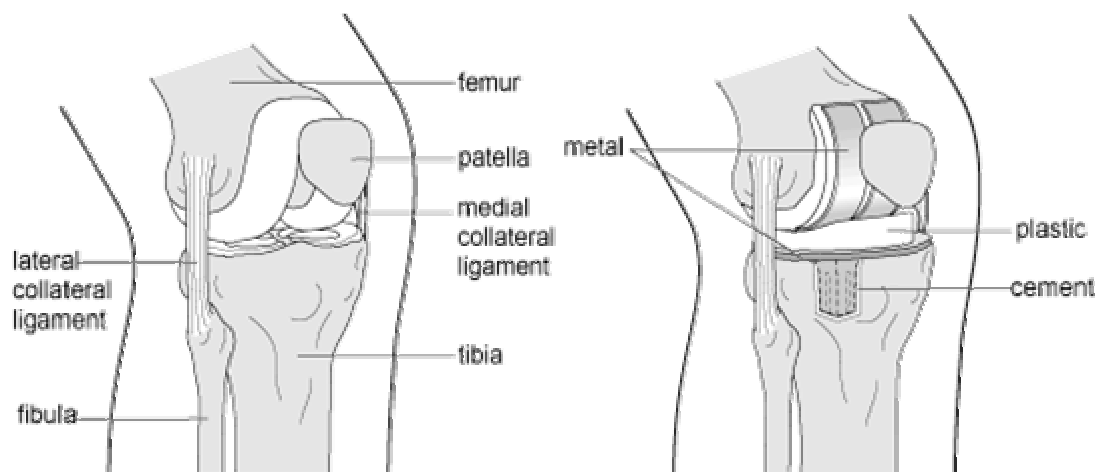


Figure 2.4: The knee joint before and after a knee replacement operation (taken from BUPA, 2008)

to be among the most painful of surgical procedures (Parvataneni et al., 2007a) and pain, though lessening, may continue throughout the period of post-operative recuperation. Approximately half of all total knee arthroplasty patients consider themselves to have suffered from 'severe pain' in the immediate post-operative period (Parvataneni et al., 2007a).

Uncontrolled post-operative pain has been found to significantly reduce a patient's ability to regain function and often delays their discharge (Ranawat and Ranawat, 2007). The necessarily invasive nature of the surgical procedure results in acute post-operative pain, particularly on ambulation (Dennis, 2004; Lingard et al., 2004). Post-operative pain levels following total knee arthroplasty are elevated in comparison to those of hip replacement patients, and though the longer-term outlook is positive, knee pain following replacement surgery may extend over a considerable time period (Lingard et al., 2004). Delayed discharge and poor post-operative outcomes have considerable financial ramifications for the hospital itself. Thus to prioritise pain control and the treatment of pain post-operatively, is to work with a variable that clinicians can manipulate. Undoubtedly, pain should be a primary focus of the post-operative care pathway (Ranawat and Ranawat, 2007).

Pain following knee surgery, has been found to be a large contributing factor in the degree to which a patient successfully regains normal function (Lingard et al., 2004) and experiences a good quality of life following their discharge from hospital. Pain has been found to be a significant inhibitor of functional activity (ANZCA, 2005). As a consequence, this may incite a vicious cycle: increased pain leads to reduced function, which may trigger psychological disturbance (anxiety, depression, low self-esteem, increased dependency on others), then generating a subsequent fear and avoidance of functional activity, causing loss of muscle tone/suppleness which engenders maladaptive postural and movement habits and increased pain (Borjesson et al., 2005; Gonzalez and Mekhail, 2004). Patients can become obsessively focussed upon their pain and the physical impairment which can accompany osteoarthritic pain. As a result of physical impairment, sufferers can avoid activity and thus social isolation and depression can result. Depression can increase feelings of fatigue which result in further physical impairment and exacerbate chronic osteoarthritic pain (McCaffrey and Freeman, 2003). The loss of independence and optimal function as a result of chronic pain is a significant problem for the mostly elderly population of osteoarthritic pain sufferers. Patients with pre-operative functional limitations, high pain levels, low mental health scores and other co-morbid conditions are likely to have worse outcomes at one and

two years post-operatively (Lingard et al., 2004). For patients encompassed by this 'at risk' group, their limited improvement at two years post-operatively indicates that there is a prolonged period of time post-operatively in which patients could benefit from continued pain management, outwith the schedule of clinical care.

Issues surrounding the importance of pain control represent a prime opportunity for implementing a multi-modal post-operative care procedure which may have considerable positive impact upon the patients. When functional recovery and psychological well-being are so intimately tied to pain control, more effective care and coping can be facilitated through a greater understanding of pain itself. It is here that a multi-modal care programme would likely result in long-term improvement in perceived care, satisfaction with surgery and ability to deal with pain in the immediate post-operative period. This programme should have the potential to traverse the boundaries between clinical care and community care, with pain and functional improvements as key indicators of post-operative improvement. The research carried out in the course of this thesis is a preliminary investigation into the concept of multi-modal care. Pain after orthopaedic surgery is certainly a risk factor and outcome measure that urgently needs more attention.

## **2.5 Cortisol: Biology and Pathology**

This section looks at a physiological marker of health status: cortisol. Cortisol is a steroidal hormone that has an extremely important functional involvement in the body's response to stress. The role of cortisol when secreted under stress is to promote the protection of the organism, directing the immune system. Cortisol primes the body for life-threatening emergency: it provides resistance to noxious stimuli and inhibits the inflammatory process that is the normal response to tissue damage. Cortisol is a glucocorticoid, and is an extremely important measure of the stability and well-being of the immune system and the body. Cortisol triggers the manufacture of glucose in order to push the Central Nervous System towards rapid response after injury, threat or other emergency (Melzack and Katz, 1999). The role of cortisol in the body is an important one. Glucocorticoids are secreted during stress in order to minimise the production of pro-inflammatory cytokines (Fries et al., 2005). Reducing cytokine levels ameliorates the inflammatory reaction and prevents tissue destruction (Franchimont et al., 2003). Cytokines play an important role in the removal of debris, repair of tissues and induction of fever in order to destroy bacteria, but they need to be

regulated. Cortisol, alongside other glucocorticoids contributes towards the inhibition of the inflammatory process that occurs when tissue is damaged. Cortisol therefore reduces inflammation and protects bodily tissue—extremely important in situations of traumatic stress caused by surgery or a car accident for example, or in the context of inflammatory conditions such as rheumatoid arthritis (Brook and Marshall, 2001). Cortisol also causes free fatty acids to be mobilised and it helps to reduce the need for amino-acids in protein synthesis (Heim et al., 2000). Cortisol provokes gluconeogenesis, the formation of glucose when glycogens are metabolised. This is achieved by regulating the metabolism of carbohydrates, as well as through mediating the organism's response to stress. As a result of more blood glucose, the body shows an increase in its energy reserves and energy supplies, allowing the body to fight off the stresses.

To understand the function and role of cortisol, it is important to describe the process by which cortisol is secreted and how it is regulated. Cortisol is secreted in the adrenal gland, alongside androgens and aldosterone. The adrenal glands are two walnut-sized glands, which consist of the outer adrenal cortex and the inner medulla. The outer cortex is the main secretory zone, and it is circled by three secretory 'rings'. The outer ring is named the zona glomerulosa, which secretes aldosterone. The middle ring is the zona fasciculata which provides cortisol, and the inner ring, the zona reticularis, secretes androgens such as Dehydroepiandrosterone (DHEA). It is the middle ring, and its steroidal hormone—cortisol—that is the focus of this section. The role and contribution of cortisol to the maintenance and dynamism of the body cannot be underestimated. Indeed, the secretions from the adrenal glands are thought to regulate almost all aspects of the functioning human body (BHD, 2006). Cortisol presents itself in the context of a delicate balance between levels of co-existing, co-dependent steroidal hormones, in a bodily system called the Hypothalamic-Pituitary-Adrenal axis (HPA axis). Any alteration in the homeostasis of the HPA axis has longer-term consequences for the immune system, given the modulatory role of glucocorticoids such as cortisol on the immune system (Fries et al., 2005). Cortisol may prime the body for emergency, but it can be a highly destructive substance: in order to maintain the high levels of glucose needed for fight-or-flight activity, cortisol breaks down the protein in muscle and inhibits the ongoing replacement of calcium in bone (Melzack and Katz, 1999). Sustained cortisol release can result in myopathy, weakness, fatigue and bone decalcification (Melzack and Katz, 1999).

Physically, the HPA axis is a triad between the hypothalamus and pituitary glands in the brain, and the adrenal glands which are situated above each kidney. The HPA axis

secretes two peptides, vasopressin and corticotropin-releasing hormone (CRH), which together provoke the secretion of adrenocorticotrophic hormone (ACTH). ACTH is an essential hormone which, when passed through the adrenal gland in the blood stream, triggers and modulates the manufacture of cortisol in the zona fasciculata. When levels of ACTH rise, then the adrenal cortex is stimulated and the biosynthesis of cortisol increases and cortisol levels rise. Higher levels of cortisol then inhibit the hypothalamus and pituitary sections of the HPA axis, and thereby reduce CRH and vasopressin concentrations, leading to lower ACTH and lowered cortisol levels. Over-stimulation of the adrenal cortex leads to imbalances in the relationship between cortisol, DHEA and aldosterone. DHEA is a steroidal hormone that precipitates levels of the sex hormones testosterone and oestrogen and is thought to contribute to immune function (Fries et al., 2005). Aldosterone importantly regulates sodium, potassium and water retention in the kidneys via vasopressin and stabilises blood pressure. The regulation of the HPA axis is linked to the strength or vulnerability of the immune system, hence any imbalances may impact upon the health and emotional well-being of the individual, as to be discussed later.

When the body is subjected to a stressful condition (either clinical or environmental), it responds by triggering the central nervous system to produce higher levels of corticotropin-releasing hormone (CRH). This activates manufacture of ACTH (Greenspan and Gardner, 2004) and elevates cortisol levels through the pathways described above. Cortisol is active endogenously in the body when needed to balance steroid hormone levels, and also is affected by exterior stressors. The central nervous system (CNS) controls these responses, and the HPA axis in combination with the CNS thereby fully coalesces the nervous system with the endocrine systems. The flow shown in Figure 2.5 clearly depicts this. Hence cortisol exists within a complex feedback loop, in a constant state of flux. This flux is regulated and adjusted through the diurnal wake-sleep cycle and in response to stressors. In general, the neuroendocrinological system of control regulates cortisol in three ways: firstly through the feedback inhibition by cortisol itself of ACTH secretion, then through the stress responsiveness of the HPA axis, and finally by episodic secretion related to circadian rhythms (Greenspan and Gardner, 2004).

Cortisol, once secreted, is found in two forms; bound and unbound (free) cortisol. Cortisol occurs immediately after secretion in a free state, but then it binds with protein in the blood plasma when it starts to move around the circulatory system (Greenspan and Gardner, 2004). Bound cortisol is usually bound to corticosteroid-binding globulin

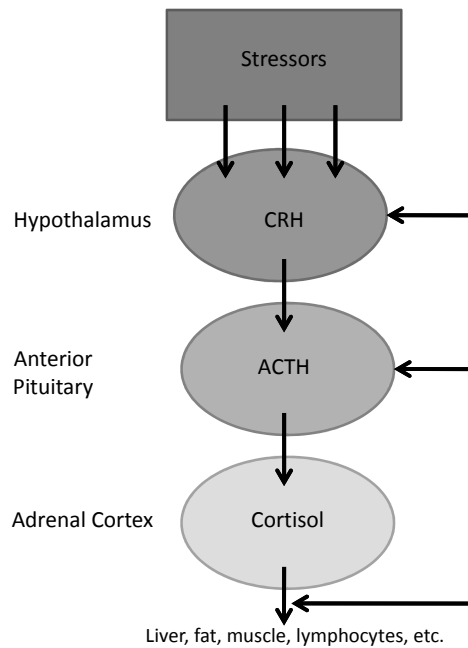


Figure 2.5: Regulation and adaptation within the hypothalamic-pituitary-adrenal axis (taken from BHD, 2006).

(CBG), but also to albumin. Bound cortisol accounts for approximately 75% of all cortisol in the body, and free cortisol represents approximately 10%. Any bound cortisol that is not bound to CBG is accounted for in the 15% which is tied to albumin. Cortisol in saliva is in its free and unbound state and it is this that is most biologically active. Both bound and free cortisol is regulated by ACTH through the HPA axis. The analysis of plasma serum and/or salivary cortisol concentrations are used as a commonplace indicator of the activity of the HPA axis and of emotional stress (Bakke et al., 2004). The concentrations of plasma cortisol to salivary cortisol are comparable with a ratio of 3:2 (Bakke et al., 2004). Although plasma cortisol can be analysed within standard medical testing procedures, saliva sampling as an alternative is a non-invasive, minimally stressful approach and is highly applicable for research purposes as a result (Bakke et al., 2004).

### 2.5.1 Stress and Cortisol

Cortisol is a unique steroid hormone, in that it is essential for resistance to the effects of noxious stimuli and stressors (Brook and Marshall, 2001), but its positive benefits may

be overshadowed by immune-system imbalances if cortisol becomes overly elevated or reduced. To define 'stressors', it is useful to divide potential noxious stimuli into four categories, all of which can subvert the diurnal rhythm, alter the levels of cortisol secretion and even completely abolish circadian rhythms if the stresses are long-standing (Al-Dujaili, 2008). The stresses described below are adapted from work by Al-Dujaili (2008):

### 1. **Physical Stress**

Physical stress can take the form of acute physical stress such as medical emergencies, surgery, car accidents for example, or chronic stressors such as constant pain, poor nutrition, food sensitivities, dehydration, too much/too little exercise and sleep deprivation. Cortisol levels may also be altered through a number of clinical disorders, namely Central Nervous System and pituitary disorders, Cushing's syndrome, liver disease, chronic renal failure and alcoholism.

### 2. **Psychological Stress**

Stress as a result of major or minor psychological disturbances, often clinical psychological problems. Principally this category includes severe anxiety, endogenous depression and the manic phase of manic-depressive psychosis.

### 3. **Emotional Stress**

Emotional stress is generally chronic and involves lifestyle issues, for example financial stress, relationship stress, work stress and chronic shortage of time.

### 4. **Spiritual Stress**

Spiritual stress is considered to be highly personal chronic stress, generally involving issues such as religion or religious disharmony, sexuality concerns and disassociation between occupation and personality, or occupation and familial expectations.

If then, stress can be caused endogenously as a result of visible or unseen clinical or physical stresses, and environmentally through psychological, emotional and spiritual stress, how exactly are cortisol secretion patterns affected? Cortisol has an extremely important role in priming the body to deal with stress. At the first sign of stress, the activation of the HPA axis and the release of cortisol from the adrenal glands shows that cortisol is a major physiological coping mechanism. Without changes in cortisol concentrations, the body would be unable to react or respond adequately to stressors and the body may remain in a problematic catatonic state. Cortisol primes the body

for danger and facilitates the flight or flight response. To activate the HPA axis stress system is to facilitate behavioural and peripheral changes that allow the organism to strive towards achieving and maintaining homeostasis, therefore improving the chance of survival (Tsigos and Crousos, 2002).

In summary, cortisol production is a natural and important method of priming the body for defensive action, be it through the fight-or-flight response, or as increased immune-system defences. Pain is a significant stressor which results in greater levels of cortisol production, in order to maintain homeostasis and respond to the threats caused by noxious stimuli. Surgery and depression are particularly high-level stresses which impact directly upon the magnitude and consistency of cortisol production. High levels of cortisol are therefore initially advantageous but subsequently potentially dangerous. Efforts should therefore be taken to reduce the magnitude of stressors, particularly in the post-operative recovery phase. It is in this context that a music-induced psychological intervention could have considerable potential. The music-specific literature detailing cortisol assessment is contained in Chapter 3.



# Chapter 3

## Music and Medicine

### 3.1 Introduction

Having evaluated pain, osteoarthritis and cortisol, it is now possible to move to directly review the literature concerning music and medicine directly. The use of music as medicine has long been associated with positive and negative effects upon the body. Since the earliest Chinese civilisations, through Pythagorean and Aristotelian philosophical traditions to modern day ‘New Age’ movements, music’s unusual affect has been deemed immensely powerful. Music has been credited with the power to ‘move’ the soul, to re-energise the body, to exert emotions and is thought to have the potential to alter the biochemical make-up of one’s innate physiology. Certainly, a universal, cross-cultural appreciation for music and the perceived ‘power of music’ has rarely, if ever, been in question (Staricoff, 2004). Whilst the direct affect of music on the body is the principal objective of this thesis, efforts must first be made to delve deeper into the music and medicine research to date, as the foundation for this study.

The use of music in a ‘clinical context’ is taken as an appropriate intervention in three possible contexts: (1) when in conjunction with the normal treatment of a patient (standard care); (2) in situations in which medication may be ‘less effective’ and therefore an adjunctive treatment may be beneficial; or (3) on those occasions when medication does not have time to take effect or is not desired, such as in the context of labour pain. Research applying to each dimension of the biopsychosocial model will be outlined in this chapter, and the relevant findings will be explained in greater depth. Clinical research will be compared with laboratory research and conclusions about the efficacy of music as an intervention will be drawn. Where possible, the studies outlined will be those which have undertaken research into pain and pain symptoms. Research

into music and medicine has assessed a wide variety of patient populations, and has been conducted with acute, chronic and laboratory-induced pain. Examples of research with different medical conditions will be outlined, and implications will be drawn for this thesis. The outlines of key research studies are delineated from page 61.

Care should be taken when interpreting the results of this research and the studies outlined: this thesis is designed as research into the effect of a *music listening* intervention. This is defined as music played for a patient during a single (but potentially replicable) episode of care to produce outcomes that were achievable during that session of music (Evans, 2002). A music listening intervention is juxtaposed against and is deliberately *not* 'music therapy'. Music therapy is a conceptually and experimentally different phenomenon. Music therapy is active music making by or with a participant (client) in the presence of a trained music therapist. Where music listening can be conducted independently via headphones or live music, music therapy is generally dependent upon positive and challenging patient-therapist interaction. Music therapy is active and practical where music listening is a passive behaviour, and music therapy is improvisatory where music listening is prescribed by the CD or music that is heard. Music therapy often strives to involve emotionally evocative music for therapeutic benefit and may utilise music that has prior associations for the patient (such as war songs). Music listening can also be emotionally evocative and the music used may have been heard before, but unless specifically outlined, it does not aim to provoke such reactions and is often deliberately emotionally neutral for the purposes of quantitative research (e.g. using experimenter-selected music).

### **3.2 Music and the Biological Dimension**

The biological dimension of the biopsychosocial model of pain encompasses the physiological changes which may or may not result as a consequence of music listening. Biologically, the key domains of relevance to this study include: pain, vital signs and cortisol. With regards to pain, the benefits of music have been demonstrated intra-operatively (Nilsson et al., 2001, 2003), post-operatively (Good et al., 1999, 2002, 2005) and with laboratory-induced pain (Hekmat and Hertel, 2003; Mitchell et al., 2006). As a consequence of the intervention, music listening has been found to limit the amount of analgesia required post-operatively (Good et al., 2001; Koch et al., 1998) and intra-operatively (Nilsson et al., 2001, 2003), and can lower the quota of rescue analgesic requested by patients (Good et al., 1999). Research with music listening and

cortisol concentration has been minimal (see only Miluk-Kolasa et al., 1994; Khalifa et al., 2003) and so implications for future research will be drawn. The influence of music listening on each of these domains will be discussed in turn, and the findings of research in these areas will be outlined.

### 3.2.1 Music and Pain

Pain is a complex personal and emotional experience that is a uniquely individual response for each pain sufferer. Melzack (1983) stated clearly that “Pain is whatever the experiencing person says it is, existing whenever he says it does” (Melzack, 1983, p. 71). As such, it is reasonable to note that the evidence surrounding the efficacy of music interventions for pain control has been equivocal. A considerable amount of research has been undertaken into music listening in an acute pain setting, but a medically validated consensus of the benefits of music has not yet been reached. An early example of audio-analgesia research was by Gardner et al. (1960). In research into dental procedures, sound (white noise or music) was found to be sufficient for pain relief and 65% of 1000 patients did not require any analgesia beyond that provided through sound. In only 10% of cases was the pain control provided by the sound thought to be less than effective. This research represented a starting point for study into audio-analgesia. Music and medicine research has progressed significantly since the 1960s, but the fundamental issues remain the same: does music consistently reduce pain, and if so, how does this analgesia occur?

One of the major proponents of research into music and pain has been Marion Good, working at Case Western Reserve University in Cleveland, USA. Good has repeatedly found that music has reduced pain in different patient populations and in diverse types of pain. To date, little research into music and pain has included large sample sizes, and Good has deliberately attempted to combat this with a series of large-scale studies, some with sample sizes of over 500 patients. Good et al. (1999) conducted a research study with 500 patients who had undergone major abdominal surgery. The patients were assessed for a period of 48 hours post-operatively for pain, analgesia, and vital signs both at rest and on ambulation. The design used in the study was a four-group randomised controlled trial comparing music listening, jaw relaxation and the combination of music and jaw relaxation against a standard care control group.

Jaw relaxation is a methodology which requires the patient to let their jaw drop, keep their tongue relaxed and lips soft and to inhale, exhale and rest with each breath-

ing cycle (Good et al., 1999). The music listening intervention groups selected a musical extract from five possible experimenter-prepared 'sedative music' options. The combination intervention combined the instructions for jaw relaxation into a pre-recorded tape which used the chosen music with relaxation instructions superimposed at regular intervals. All interventions were used daily in the post-operative period for one hour each day. The results of the study showed that 84% of the music group found that their pain was reduced moderately or 'a lot'. The music group and the relaxation group showed less pain at rest than the control group. The combination group, however, showed less pain at rest and ambulation on post-operative Day 1 than the other two intervention groups.

Using the same format and the same musical examples, Good expanded this research to other patient populations (Good et al., 2002, 2005; Good, 2008). Results showed that music, jaw relaxation and their combination resulted in less pain on Days 1 and 2 at rest, but unlike in the results of the 1999 study, there was no difference between the experimental groups and no advantage of the combination strategy following major gynaecological surgery (Good et al., 2002) or intestinal surgery (Good et al., 2005). Across the studies and in response to relaxation, music and their combination, participants exhibited as much as a 29% reduction in their perceived pain. Though Good et al. (1999) found that a combination approach to pain management via music listening and jaw relaxation was most advantageous, the later studies showed that there were no significant differences between intervention modalities. It seems therefore that a number of interventions may be active in pain management. In this case, what is the advantage of music over other intervention strategies? This important issue will be discussed in full in Section 3.3.

The studies described above investigated the relationship between *post-operative* pain and music listening. Research has also been conducted into the *intra-operative* use of music for pain relief (Nilsson et al., 2001, 2003). In their first study, Nilsson et al. (2001) investigated whether the intra-operative use of music and/or therapeutic suggestions effectively reduced post-operative pain, nausea and mobilisation. Female patients scheduled for abdominal hysterectomy were randomised three groups. Either (1) 'relaxing and calming' music accompanied by sea sounds, (2) music with superimposed relaxing therapeutic suggestions, or (3) recorded operating room sounds. Intra-operative music reduced post-operative pain on Day 1, shortened the time to mobilisation and lowered fatigue levels post-operatively when in comparison to the control group. The music and therapeutic suggestions group also displayed reduced fatigue

and improved mobilisation. The music intervention, however, was most effective for pain relief. Soothing music heard on its own intra-operatively was more beneficial than combining that music with therapeutic suggestions.

Extending this research, Nilsson et al. (2003) compared the effects of new age synthesised music, heard either intra-operatively or post-operatively, against silence. In the three-group randomised controlled trial, results showed that the intra-operative and post-operative music groups reported greater pain reduction at one and two hours post-operatively. In addition, the post-operative music group required less post-operative morphine at one hour after surgery. This study shows, therefore, that listening to music intra-operatively has the potential to lower post-operative pain, and this is comparable to listening to music post-operatively, though post-operative listening potentially has the advantage of concomitant reductions in required PCA morphine. Nilsson et al suggest that the pain-relieving benefits of music listening are advantageous, but that they are time-limited to only one to two hours after completing the music listening. This factor of the residual nature of audio-analgesia has been little investigated and requires further research.

Pain is a function of both a sensory and affective experience (see Chapter 2 for further detail). If audio-analgesia is to be totally effective, it must resonate across both dimensions.<sup>1</sup> Exploring labour pain, Phumdoung and Good (2003) explored sensory and distress ratings for the first three hours of the active phase of labour. Thai women listened to sedative music or no music for three hours as active labour commenced. Sensory and affective distress of pain were measured via 100mm visual analogue scales and qualitative information was collected via a feedback interview. Those women in the music group had significantly less pain sensation and affective distress at all intra- and post-intervention time-points. Where the control group displayed a rise in their distress levels immediately as active labour commenced, the music delayed an increase in affective distress for one hour. In feedback, 98% of patients found that the music had been helpful, though the effects were heterogeneous and better for some participants than others. Music then can impact both sensory and affective components of the pain experience and future research must make a concerted effort to use discriminative measures to investigate this further.

The research reviewed thus far has been conducted with acute pain populations. A small amount of research has also included chronic pain participants, generally as-

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<sup>1</sup>It must be noted that the sensory and affective components of pain are not necessarily in a one-to-one relationship, therefore changes may occur on one but not the other dimension even in the context of an 'overall' pain reduction.

sessed in a familial context. That music is effective for pain control with chronic pain sufferers has been shown by Carroll and Seers (1998). Chronic cancer pain patients were asked to listen to 30 minutes of relaxing instrumental music or were allocated to the control relaxation group who rested in a room with dimmed lights. In comparison to the control group, the music group showed reduced intensity of pain scores and lower pain on all dimensions of the McGill Pain Questionnaire post-intervention. In another study into music and chronic pain, McCaffrey and Freeman (2003) suggested that music does not just reduce chronic pain, but that this pain reduction is cumulative. McCaffrey and Freeman (2003) noted that the longevity of the benefits of music listening were rarely noted and the limited results available could not provide a consensus on either the efficacy of music listening for chronic pain relief, or the long-term benefits of a music intervention. Sixty-six older persons with chronic osteoarthritic pain were either asked to listen to 20 minutes of relaxing classical music daily in the morning for two weeks, or to spend that time in quiet relaxation. The results showed that the experimental group had a significantly better reduction in pre- to post-test pain on all days of testing. Interestingly, the scores also showed a cumulative decrease in pain across the weeks of testing (Days 1, 7 and 14) for the music group, but not for the control group. This would suggest that music listening may have an immediate pain-relieving effect, but also a cumulative pain-relieving effect. The experimental design of the acute pain study in this thesis was designed to investigate further the potential of cumulative audio-analgesia.

The studies reviewed thus far would seem to indicate that a music listening intervention is appropriate for pain reduction in acute and chronic pain settings, post-operatively and intra-operatively. Music listening can reduce the sensation and distress of pain and limit the amount of intra- and post-operative analgesia required by patients. Yet the question arises: are there any research studies that contradict this body of evidence? MacDonald et al. (2003) conducted two studies researching the impact of music on pain with two different patient populations. Participants were requested to bring their own choice of CD to the hospital for use as much as possible in the post-operative period (minimum listening time: 45 minutes). The first study worked with patients undergoing minor foot surgery. These results supported the use of music as a method of anxiety reduction, but showed no reductions in pain at any stage of testing, though lowered anxiety levels were demonstrated. The results from the second study conflicted with this possible anxiolytic effect. In the second study, abdominal hysterectomy patients listened to music as often as possible for 72-hours post-operatively.

Though pain levels and anxiety scores diminished across the course of the study, there was no difference between groups in pain reduction or anxiety reduction.

MacDonald et al. (2003) hypothesised that the conflict in the results may have been due to the difference in the personal salience of the different surgical procedures. Hysterectomy surgery is significantly more complex surgery than minor foot surgery and is a highly emotional event, surrounding the loss of a woman's womb. Where foot surgery patients remained isolated on the ward, hysterectomy surgery seemed to precipitate group cohesion. The homogeneous single-gender hysterectomy surgery population displayed a positive group dynamic with participants engaging in group discussion. In this context, it was considered possible that the social isolation induced by listening to music on a personal CD-player was negatively perceived. Music listening therefore did not offer the same degree of relational support as relational group involvement. Whatever the theoretical reason for differences in the results, the finding regarding pain reduction was the same: music listening did not induce pain relief in this study.

Ikonomidou et al. (2004) also found that music did not induce audio-analgesia after laparoscopic gynaecological surgery. Sixty female patients listened to peaceful panpipe music or no music for thirty minutes before surgery and thirty minutes after surgery. Though there were consistent changes in physiological markers, there were no differences between groups in pain scores. This was true despite the fact that 74% of the patients in the music group stated that they enjoyed the music and found it beneficial. It seems then, that though there is a body of evidence which might suggest that music can induce audio-analgesia, the stability of this effect is questionable. Throughout the studies outlined above, it is noted that many different types of music were used and many different assessment tools were employed for pain measurement. It is perhaps the lack of methodological standardisation that has led to confusion in the field. Inter-study differences have primarily been in the music used in research and in the assessment measures by which participants were monitored. The differences in and rationale behind musical choices will be outlined in Section 3.3 and Chapter 4. Regarding assessment, work by the IMMPACT task force (see Chapter 2) has suggested a library of assessment measures which are most appropriate and should be used in clinical research. Through the integration of standardised, rational musical selections and appropriate measurement tools, the field of music and medicine should move towards a reliable and consistent consensus within the forthcoming years.

### 3.2.2 Music and Cortisol

Cortisol is a dynamically-active hormone which responds within two minutes to personal or clinical stress (see Chapter 6.3). Minimal research has been undertaken into the efficacy of music in reducing the production of cortisol created by the HPA axis in response to a pain-related stressor. That research which has been undertaken has suggested that music can impact upon cortisol concentration. However, the majority of research into cortisol concentration has been in the context of generic stress, not pain-induced stress. Only one study has investigated the use of music in stress management in a clinical setting. Miluk-Kolasa et al. (1994) monitored 34 patients scheduled for surgery the following day for their salivary cortisol concentration levels. On receipt of the information concerning their surgery the following day, all patients demonstrated a mean 50% rise in their cortisol concentrations. Following this stressor, half of the patients were given music for one hour, and half were not. Those patients who were exposed to music showed a marked reduction in their salivary cortisol levels in comparison to the control patients. Therefore, music was thought to alleviate stress pre-surgery and post-stress.

In a similar study into cortisol production and stress but outwith a clinical setting, Khalfa et al. (2003) investigated the impact of music on laboratory-induced psychological stress. Based on the premise that listening to music may be effective at reducing the negative effects of stress on the HPA-axis, 24 healthy male participants were exposed the Trier Social Stress Test (TSST). This test requires participants to perform a simulated interview and a mathematical subtraction task to induce stress in healthy participants. Participants were assessed for salivary cortisol concentrations pre, post and during the recovery period following the stressor. Half of the participants listened to relaxing music during their recovery and half rested in silence. Those who listened to music in the immediate post-stress period showed a significantly more rapid reduction in their salivary cortisol concentrations in comparison to the control group. Though both groups returned to baseline by the end of the 45 minute of rest period, in the first phase of recovery the cortisol concentrations in the music group went down, whereas those of the control group continued to rise. Relaxing music following the TSST had the power to decrease the post-stress response of the HPA-axis and this may have been attributable to a distraction effect. Music enabled music participants to shift their attention away from ruminating on their previous performance, to relaxation and recovery.



To date, no music medicine research has yet included cortisol as a measure of physiological stress precipitated post-operatively by surgery. Though studies (as above) have investigated music-induced cortisol alterations in situations of laboratory-induced or pre-surgical stress, this research has not encompassed post-operative clinical stress responses. It is likely that due to the severity of a surgical stressor and the concomitant challenge to the immune system, cortisol may behave differently. Clinical stress presents a greater challenge to the organism physically and emotionally and may require greater effort on the part of the Central Nervous System and HPA-axis to maintain homeostasis. Research has shown that pain-evoked autonomic responses are closely linked with pain affect (Rainville et al., 2005). If music has the ability to improve affective mood state, then it may demonstrate concomitant alterations in autonomic state. Integrative stress concepts (Schneider et al., 2001) suggest that fear and stress activate neurophysiology. This results in greater secretion of stress-indicating hormones such as cortisol and catecholamines. Changes in cortisol concentration following surgery and in response to a music intervention, are therefore an interesting and necessary avenue of exploration. In addition, no study into music and cortisol has, as yet, evaluated the contribution of different musical extracts to stress reduction. Miluk-Kolasa et al. (1994) simply stated that they used 'music' and Khalfa et al. (2003) that they used 'relaxing music'. Further research is required to find out whether different categories and types of music may induce differing degrees of cortisol reduction following stressors.

### **3.3 Music and the Psychological Dimension**

To move now to the psychological dimension of the biopsychosocial model of pain. Psychological methods are those which attempt to assist the patient in changing their perception of the events taking place, thus resulting in a different or more favourable reaction from the individual (Stevenson, 1995). The role of music across the psychological dimension is thought to depend on its ability to operate as a cognitive-coping strategy and as a distractor and relaxant. These factors will be outlined first, followed by factors which direct the personally relevant outcomes of music listening: preference, locus of control, and emotional resonance. Finally, the role of anxiety and depression in pain research will be defined.

### 3.3.1 Music as a Cognitive-coping Strategy

Just as pain affects cognition, cognition can affect pain and cognitive-coping strategies are powerful in this regard. In relation to this thesis: “the brain that engages music is changed by engaging in music” (Thaut, 2005, p.303). Music engages the central nervous system by absorbing attention and therefore modulates the distribution of the remaining attentional resources that would be utilised for pain processing. As outlined in Chapter 2 and on page 14, cognitive-coping strategies are thought to be the primary psychological method in which music may act upon pain perception. Cognitive-coping strategies are often innate or acculturated and have been learned from a young age. Methods such as diverting a child’s attention to an interesting object when they fall and hurt themselves, or maintaining high levels of activity when tired to absorb one’s attention in a task which enables the displacement of fatigue, are both cognitive-coping strategies with somatic results. In this way, music is highly familiar as a cognitive stimulus and is regularly used for attention diversion from repetitive tasks, for example. Music is engaging and stimulating and occurs in every culture, in every country (Sloboda, 2002). From an early age, music listening is an everyday experience, thus it may be highly relevant as a familiar cognitive-coping strategy.

The inter-connectivity between pain and psychology is such that cognitive-coping strategies can be powerful. Fernandez and Turk (1989) found that cognitive-coping strategies had a 85% success rate in attenuating pain ratings, enhancing pain tolerance and raising pain thresholds as compared with no treatment. Cognitive-coping strategies are most effective if they are relevant to the pain context and are appropriately absorbing. They are thought to be mediated by the ability of the person to apply the cognitive-coping strategy. If the participant is not adequately absorbed in the coping strategy, then the benefits of the strategy may be minimal. Therefore, music itself may not automatically induce the desired pain relief and physiological or psychological changes unless listeners actively engage with the stimulus by whatever means they find appropriate (Sloboda, 2002). The power of music is not a ‘pharmaceutical property of the sound stimulus’ (Sloboda, 2002, p.384), but is a tool which can either be used effectively or remain untouched. Good et al. (1999) noted that the responses to music as a method of pain management were more effective if the patient were able to concentrate on the intervention. Similarly, with labour pain, music as a strategy for pain management was effective, but patients demonstrated heterogeneous effects (Phumdoung and Good, 2003). It is therefore likely that some participants were more

effective at focusing on the music than others and that this dictated the magnitude of music-induced audio-analgesia. Providing opportunities for 'focused attention' on the music promotes absorption in the stimulus and fosters an improved ability to cope with and greater distraction from pain. In this way, music may also provide a temporal space in which patients can reinforce and re-use the cognitive-coping resources and skills which they have already learned (Hekmat and Hertel, 2003), such as distraction and relaxation.

Cognitive-coping strategies are not intended as one-dimensional interventions. In research into non-pharmacological strategies for pain and anxiety reduction following total knee and hip arthroplasties, Pellino et al. (2005) asserts that cognitive-coping strategies and prescribed analgesics function together as an effective 'kit'. Including music in multi-modal pain management adds it to the 'kit'. But is music as effective as other cognitive-coping strategies, and why should it be prioritised over other methods? Music's function as a cognitive-coping strategy has been compared against other cognitive-coping strategies by Mitchell et al. (2006). Forty-four healthy participants were asked to complete a cold pressor task in which music was compared against humour and a mathematical task. Humour has been found to successfully reduce muscular tension, respiration rate and galvanic skin response. It may also improve and increase endorphin levels, and pressure pain threshold (Mitchell et al., 2006). Mathematical tasks have been regularly used as an emotionally neutral, but attentionally absorbing cognitive-distraction task (Fernandez and Turk, 1989). In comparison against humour and mathematics, Mitchell et al. (2006) found that preferred music improved tolerance of the painful stimulus and participants' perceived locus of control throughout their pain task. Though humour was also effective at improving pain tolerance, its neural affect meant that perceived control over pain was low and therefore music was a more appropriate strategy.

Nilsson et al. (2001) compared music with 'music and therapeutic suggestions'. A comparison between the two intervention groups and against a standard care control group found that the combination intervention did not induce any greater pain relief in the context of elective hysterectomy. In fact, music was more successful at mobilising patients earlier and reducing their pain and fatigue. Though more research is needed into audio-analgesia versus other cognitive-coping strategies such as guided imagery, pain focusing and attention-redirecting, it seems likely that music is an advantaged strategy in many ways. Music is a highly familiar stimulus that has an innate ability to hold attention (Mitchell et al., 2006). Mitchell et al asserted the importance

of utilising an emotionally engaging stimulus following Leventhal (1992). Music is immediately emotionally engaging and people have strong reactions and opinions regarding their emotional identification with music (Hargreaves, 1986; Sloboda, 2002). Music can invoke emotional responses from prior associations with the music and can evoke memories, as will be addressed in Section 3.3.5. In addition, cognitive-coping strategies which involve numerous sensory modalities appear to have the most power to divert pain-related thought patterns (Fernandez and Turk, 1989). Music operates biologically, psychologically and sociologically and therefore has considerable potential in this regard.

### **3.3.2 Music, Distraction and Relaxation**

It has been established that music can function as a cognitive-coping strategy, and that it may be a privileged method as such. Theoretical questions arise, however, surrounding 'how' music functions as a coping method. To review, cognitive-coping strategies may be categorised as: (1) imagery, (2) self-statements and (3) attention-diversion techniques. Music acts as a vessel for imagery and is in essence a self-statement of taste and preference, but it is primarily an attention-diversion technique. Distraction is the deliberate replacement of of an existing stimulus (for example, a noxious stimulus) with a more pleasant focus of attention. Distraction can be deliberate or unconscious. Distraction is not a method by which the pain can be made to disappear, but makes pain more bearable by replacing it with another focus of attention, thus increasing pain tolerance (Stevenson, 1995).

Distraction is highly inter-connected with relaxation. With a positive renewal of focused attention, muscular tension may be released and the patient may feel more 'relaxed' (Voss et al., 2004). Relaxation is also exhibited as a lack of awareness of the social context in which the distraction is taking place; a 'loss of time'. In listening to music, patients' awareness of time passing can become hazy as they focus on the music, thus promoting the relaxation response (Cooke et al., 2005; Guzzetta, 2000). Relaxation is also associated with the increased comfort levels shown in patients engaging with a music listening strategy (McCaffrey and Good, 2000; Stevenson, 1995). Relaxation is thought to attenuate the affective distress component of pain and is facilitated by distraction which is thought to operate on the sensory modalities of pain perception (Stevenson, 1995).

Pain sufferers often spontaneously use distracting cognitive-coping strategies as a

method of pain control (McCaffrey and Freeman, 2003; Mitchell et al., 2006). 93.3% of patients given a music listening intervention whilst undergoing a cerebral angiogram found music helpful during the procedure (Schneider et al., 2001). 71.4% of these patients attributed this to a distraction effect. Good et al. (2005) directed patients to use music in a post-operative pain context to relax and distract, and 52% of patients deliberately used the music in both ways. The remaining patients considered music to be a distraction, or were thought to have developed their own ways of listening to music. A phenomenological analysis of patient's qualitative responses to a music listening intervention (McCaffrey and Good, 2000) showed that all participants reported feeling distracted from their pain, fear and anxiety when listening to familiar genres of music. Patients reported that this distraction enabled them to focus on their healing rather than on their feelings of frustration, pain and fear. Nurses working with the music listening patients reported that they were more relaxed than other patients and were experiencing less pain.

Music therefore undoubtedly functions as a distraction and concurrently facilitates relaxation. Yet it is also possible that this distraction is two-directional. Following Chafin et al. (2004), perhaps improved pain tolerance may be the result not just of diverted attention away from the stimulus, but distraction may prevent negative rumination about the noxious stimulus or stressor. Research into laboratory-induced stress would suggest that this hypothesis is valid. As outlined above, Khalfa et al. (2003) attributed the descent in salivary cortisol concentrations following the Trier Social Stress Test to a distraction that enabled participants to avoid repetitive negative thought about their performance on the test. Further research would enable conclusions to be drawn about whether this also applies to noxious stimuli such as significant pain following surgery. The results of this thesis are designed to provide insight into the issues surrounding the mechanisms of pain reduction, whether they may function via distraction, relaxation or their combination.

### **3.3.3 Musical Preference**

If music's power as a cognitive-coping strategy and attention-diversion technique is thought to be related to the degree of absorption in the stimulus and the extent of emotional identification with the stimulus, then preference is a key issue in music and pain research. To listen independently to music is necessarily to select and choose the music that is heard. Preference refers to an act of choosing, esteeming or giving advantage

to one thing over another (Burnsed, 1998). The reasons for choosing are thought to be based on “the interaction of input information and the characteristics of the listener, with input information consisting of the musical stimulus and the listener’s cultural environment” (LeBlanc, 1987, p.139). The use of music in a clinical context typically uses three different methods of selecting music for the experimental research. These are defined by the degree of autonomy granted in the process of musical selection:

1. **Non-Preferred Music**

Music which is selected by the experimenter and which has not been heard by the listener before the intervention or time of testing. The participant is not involved in selecting the music in any way and the musical selection may therefore either be in accordance with or unsuited to their personal tastes.

2. **Preferred Music**

Preferred music is entirely self-selected by the participant from their own personal musical collections. The musical choice is in no way influenced by the experimenter.

3. **Quasi-Preferred Music**

Quasi-preferred music is an integrative approach that involves both the experimenter and the participant. The experimenter prepares a battery of possible musical examples and the participant selects a preferred extract from the possible samples. In this way the participant has some control over what they listen to, but the experimenter retains the right to bias the musical library in line with the experimental rationale and desired testing criterion.

Non-preferred, quasi-preferred and preferred musical selections have all been utilised in research to date. To look first at non-preferred music; a significant proportion of research into music and pain has asked participants to listen to music which was experimenter selected and over which they had no influence. Participants have been given relaxing classical music (McCaffrey and Freeman, 2003), panpipe music (Ikonomidou et al., 2004), relaxing music (Carroll and Seers, 1998), music with sea-sounds (Nilsson et al., 2001), or new age synthesised music (Nilsson et al., 2003), for example. All of these extracts were prescribed by the experimenters and although they are significantly different, they were all deemed suitable for the context of the research by the study authors. Non-preferred music represents a methodology by which the experimenters select music which is ‘appropriate’ for the research and which may exhibit a particular

musical construct which is of interest for the research. Yet non-preferred music may not be appropriate to the listeners' personal tastes and may be disliked by the listener. Research has shown that over half of respondents would prefer to listen to their own choice of music in a clinical context (Hyde et al., 1998). Though a clear experimental design is important for clarity in research, it seems difficult to justify this methodology in light of an ethical desire to ensure that experimental interventions are appropriate to the individual patient.

Research seems to validate this position. Roy et al. (2008) investigated the importance of choice through research into pleasant or unpleasant non-preferred stimuli. Eighteen university students were asked to evaluate their mood, pain intensity and unpleasantness when exposed to thermally-induced pain. Participants were played pleasant or unpleasant music or silence. It was found that pleasant music reduced pain compared to unpleasant music or silence, though unpleasant music did not affect or increase pain as might be expected. The analgesic effect of pleasant music was correlated with the level of preference (liking) for the music by the participant. Participants who particularly enjoyed the pleasant music showed greater pain relief than those who found the music pleasant but not highly valued. These results suggest that liking for music is important for the patient, but also correlates with the degree of audio-analgesia that can be induced. This confirmed the results of the study by Hekmat and Hertel (2003) which compared non-preferred music with (positively valued) quasi-preferred music for attenuating pain and improving tolerance for experimentally-induced cold pressor pain. Quasi-preferred music significantly improved pain tolerance over non-preferred music. Also, both music groups showed attenuation of their pain in comparison to no music. Allowing the participants to select their music was therefore advantageous for pain relief.

Quasi-preferred music offers an opportunity for the participant to retain autonomy in their treatment, but for the experimenter to manipulate their selection in the desired direction, for research purposes. In this way quasi-preferred music provides an excellent opportunity for experimenters to investigate specific musical constructs, but for participants to maintain autonomy in their selection according to their personal preferences and enjoyment. This manipulation must be carefully designed in order to maintain verisimilitude in the possible selections. The research by Hekmat and Hertel (2003) used only electric organ music for participants to choose from. Though participants could select one 'quasi-preferred' track from five organ extracts, it is unlikely that the selection of organ music offered allowed participants to select music that

was representative of their own taste culture. This may have restricted their levels of autonomy—important for analgesic gain and increased pain tolerance. Quasi-preferred music which is perhaps closer to ‘real’ musical tastes has been used in a number of research studies (see Good et al., 1999, 2002, 2005; Phumdoung and Good, 2003; Voss et al., 2004, for examples). These studies all used the same selection of music which encompassed a range of musical styles from popular to new age and classical, but ensured that the selections were all examples of music with sedative properties.<sup>2</sup> In this way quasi-preferred music successfully furnished the participant with choices that may have been similar or applicable to their ‘real-life’ listening habits, but which were controlled by the researcher for the purpose of inducing ‘sedative effects’.

When selecting ‘quasi-preferred’ options for participants, care must be taken not to ‘assume similarity’. It cannot be presumed that other listeners hold preferences, beliefs and values which are similar to ours. The same applies to musical tastes: it cannot be assumed that what is liked by the experimenter will be enjoyed by the listener. The musical choices that are offered must therefore be relevant to the patient population but allow for a diversity in taste. The selection offered must be wide enough for participants to select an option that they like and that is potentially similar to their particular musical taste culture. This is particularly important where cultural differences may occur. Good et al. (2000) reviewed cultural preferences for music in a clinical setting and found that offering culturally specific music improved the likelihood of patient choice and acceptance of the music. Where Caucasians chose to listen to orchestral or popular piano music (63%), African Americans preferred jazz music (100%) and Asians chose harp music (31%), but never jazz music. Voss et al. (2004) included American-Indian flute music as a quasi-preferred choice in their research study as the location of the study was an area with a large Native American population. That musical choice was consequently positively received and found to be culturally relevant. Likewise, Lai (1999) and Wang et al. (2002) added Chinese music, Buddhist religious music and oriental new age music to their possible music selections for a Taiwanese population. Commonalities of response between listeners are dependent to a large degree on the relative similarity between their intentions, beliefs, cultural background and experience (Sloboda, 2002). Being culturally aware and ethnically relevant is therefore a prime consideration when preparing a musical selection for quasi-preferred music which is designed to investigate a group response such as analgesia.

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<sup>2</sup>Sedative music has been defined by Good et al. (2000) as music without lyrics and with a sustained melodic quality. It must have a tempo that models the resting pulse: between 60 and 80 beats per minute. It must also show a general absence of strong rhythms or percussion.



Lastly, to preferred music: the rationale for preferred music is an extension of that behind quasi-preferred music. Where quasi-preferred music allows for some autonomy in musical choice, preferred music offers complete independence. The experimenter is not involved at all in the musical selection and the participant may choose any music that they deem desirable from their own music collections. In this way, their musical choice may foster a greater sense of self-efficacy in treatment and involvement with the music (Hekmat and Hertel, 2003). Using preferred music reflects the awareness that, like pain, music is a unique experience and musical taste or preference is the result of gender, age, culture, present mood and attitude, for example. Research has shown that preferred music is an effective cognitive-coping strategy for increasing pain tolerance, in comparison with humour or arithmetic tasks (Mitchell et al., 2006). Preferred music has also demonstrated anxiolytic effects (MacDonald et al., 2003). Yet preferred music has not shown reduced intensity of pain in the post-operative period, unlike both non-preferred music and quasi-preferred music. This may be because the music that is selected by participants is extremely broad and thus it proves difficult to generate a consensus in the results.

It is also possible that preferred music is selected by participants for very different reasons than quasi-preferred musical options are chosen by experimenters. Preferred music may be chosen for personal and emotional reasons, perhaps because of lyrics with which the person identifies, or because the music recalls specific memories. These personal reasons may be both positive and negative in affect and therefore may govern the reaction of the patient via a learned association when they listen to the music. In contrast, quasi-preferred music is generally neutral, but of a broadly preferred 'type'. The neutrality of the music provides the opportunity for patients to imbue the music with new meaning. Just as a previously learned association provokes memories or emotions, meaning can be granted to neutral music. For example, patients in a hospital setting may learn to associate neutral quasi-preferred music with a positive break in their day and as an initiator of a distraction/relaxation response. The benefits of both emotionally-evocative and emotionally-neutral music are evident, but are conceptually quite different uses of music. In clinical trials where research design tends towards rigorous empiricism, perhaps quasi-preferred music offers greater flexibility and transparency for assessing audio-analgesia. The effects will (ideally) not be related to previous events or ingrained responses to the sound stimulus, but will be new, fresh and purely a function of the research. Preferred music, by contrast, may be more appropriate to phenomenological or qualitative clinical research due to the significant

differences in music that will inevitably be chosen and the particular salience that those selections may have for each individual patient.

Overall, non-preferred music neglects the individual's response to music and risks selecting inappropriate and irrelevant music that has been chosen for assumed relaxing or analgesic effects (MacDonald et al., 2003). Quasi-preferred music promotes the autonomy of the individual and facilitates a sense of agency in treatment, but still maintains the option of experimental manipulation of the stimuli. Quasi-preferred music can also be emotionally neutral music and therefore presents opportunities for fresh responses to the sound. Preferred music fully accounts for the uniqueness of the individual in their musical tastes and offers the patient a significant degree of control over their own treatment. However, preferred music may be problematised by its innate heterogeneity and an inability to fully account for the specific action of musical constructs on pain, beyond the generic use of music as a distracting cognitive-coping strategy. In summary, it is important to appreciate that any music listening intervention for pain should aim to be applicable to all pain populations and in all contexts. Participants should be able to replicate the intervention upon completion of the study. Music that is used in pain research should be available commercially so that if patients find the music beneficial, they can utilise this or similar extracts themselves. Considering issues of music preference before prescribing the method by which music is chosen is important. If participants are involved in their musical choice, the likelihood that they will replicate the music listening intervention outside of the clinical context is greater.

### **3.3.4 Locus of Control**

In a clinical setting, opportunities to get personally involved in one's own care are rare. Hospitals have established protocols, procedures and care pathways and the patient is to some extent impotent to influence these. This can leave the patient with feelings of vulnerability, a lack of understanding of their treatment, concern about their well-being and frustration at their rate of progress towards recovery. Essentially, the patient has a low 'locus of control': a low or limited ability to get involved with or impact upon their own treatment. The patient is therefore unable to improve their clinical status or to prepare physically and psychologically for their treatment and for the passage towards recuperation or total recovery. Enabling patients to develop a sense of agency in their treatment, thus improving their locus of control can significantly assist in recovery rate and can heighten patient satisfaction with treatment (McCaffrey and Freeman, 2003).

Music can be used in this way: music listening not only facilitates cognitive-coping and attention diversion, but also presents the patient with a pleasant and enjoyable modality with which they can engage personally, emotionally and physically.

McCaffrey and Good (2000) conducted phenomenological research with a small sample of nine post-operative surgical patients. The patients were able to use a selection of twenty musical tapes at any time during their stay and were able to change their music as desired. The results of the study confirmed the issue of locus of control as important to patients. Music gave the participants greater control of their environment and the potential for active participation in their healing process. It facilitated a positive mental shift in the patients, enabling them to envisage being in other, more pleasant locations. The music allowed personal alteration of the meaning of the painful sensation and re-conceptualisation of this in positive terms. The music provided familiarity and comfort for patients in an alien environment. Using music to accompany tasks or to support a patient in a clinical setting is a way of returning autonomy and personalisation back to the patient and to their treatment. In a later study, with elders suffering from chronic osteoarthritic pain in a familial context, McCaffrey and Freeman (2003) found similarly that music listening improved motivation, elevated mood and emphasised feelings of responsibility and control.

Essentially, when patients engage with music, or listen to music in an effort to reduce their pain, they are participating in changing their pain state (McCaffrey and Freeman, 2003). Within a clinical setting, music invites patients to improve their locus of control by presenting them with an easily accessible, non-invasive, inexpensive and enjoyable intervention. That this modality may also have concomitant physiological and psychological benefits further elevates the locus of control. Music can be listened to at any time and in the majority of contexts and is therefore vastly suitable as a modulatory intervention for pain control. In the bounds of a research study, offering patients the chance to become involved in their musical selection either through quasi-preferred or preferred music improves their sense of agency in both the research and in their treatment. Music therefore improves patient satisfaction with treatment (Biley, 2000; Cabrera and Lee, 2000; Evans, 2002) in addition to fostering a sense of independence and heightening the locus of control.

### 3.3.5 Emotional Resonance and Personal Salience

As outlined above in reference to preferred music, music is, to a great extent, highly personal and has much emotional resonance.<sup>3</sup> What is the neurobiological explanation for this? Auditory stimulation via music listening is thought to influence the limbic system. The limbic system represents the centre of information processing for emotions, feelings, memories and sensations (Cooke et al., 2005). That music perception is so powerful for inducing affective emotions is a primary indicator that music and the limbic system interact and that the limbic system engages with the processing of musical stimuli (Lai, 1999). The hypothalamus is a major output pathway of the limbic system (Lai, 1999) and is implicated in the parallel processing of sensory-perceptual and cognitive-emotional functions of the mind with bodily physiology (Lai, 1999). Through the limbic system, psychological and physiological responses are primed: it is thought that auditory stimulation may reduce the neurotransmitter ability to relay uncomfortable or affective feelings in the limbic system (Lee et al., 2005b). When auditory stimulation occupies neurotransmitters, it diverts feelings of anxiety, fear and pain and results in a more positive perceptual experience (Thaut, 1990). This explicates the uniquely affective character of music as a mood changer and mood enhancer (Sloboda, 2002). Concurrently, music also stimulates the release of enkephalins and endorphins which are mood altering and pain relieving (Cooke et al., 2005). Music is a highly effective inducer of emotion and experiencing pleasant valence or positive emotion when listening to music has been found to reduce pain (Roy et al., 2008). Music or auditory stimulation therefore refocuses attention towards pleasant emotional states.

That music can function as a mood enhancer is an important consideration. Roy et al. (2008) conducted research into the experimental manipulation of musical valence in audio-analgesia. Healthy University students were asked to listen to music which was perceived of as pleasant or unpleasant, whilst experiencing pain as a result of noxious thermal stimuli. The results showed that anger, anxiety, pain intensity and unpleasantness were rated as lower when the listener had been exposed to pleasant music. When this pleasant music induced positive emotion, the analgesic effect was significantly greater, as was the induction of positive mood. It is important then, that music used in clinical research is both pleasant to the listener and liked by the listener. In this way its personal salience is greater and the potential for analgesia is maximised.

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<sup>3</sup>This section is not intended as a review of all music and emotion literature—that would be beyond the scope of this thesis. Instead it addresses the importance of the individual experience of music listening in the context of acute or chronic pain.

Even under conditions of mental distress as a result of anxiety or depression, music can induce mood changes. In a Taiwanese mental health unit, music listening induced a mood state of tranquillity in depressed patients (Lai, 1999) and music listening during a cerebral angiogram was particularly effective for anxious patients (Schneider et al., 2001). That patients deliberately choose music for the purposes of changing mood state has been shown by Sloboda (2002), and this was particularly notable in situations in which the patient was involved with mundane tasks. When tasks are undesirable, or to extend this, when pain is unwanted, music can be used to elevate levels of positivity. In this way, music plays a very powerful role in the provision of comfort for patients.

Music can also invite reminiscing (Lai, 1999). Listening to music provides space for thoughts about the personal salience of the music, principally whether it has been connected with previous events or feelings. If so, music can invoke those feelings and memories. If the music is unknown, it may still promote reminiscing, as the function of music as a cue to reminisce or become nostalgic is the single most reported use of music (Sloboda, 2002). Even when music cues sad emotions, this can have therapeutic gain for the patient as it allows the arousal of negative feelings that may have been repressed and the music acts as a vessel for the expression of these emotions (Lai, 1999). In essence, music promotes non-verbal emotional catharsis. Unknown music can also function as an opportunity to explore mood and to associate the new music with the current events (see page 44). Neutral music may also, for example, have constructional, melodic or timbral features comparable with similar music that has been previously heard, thus it can provide familiarity in an unfamiliar (clinical) setting (McCaffrey and Good, 2000).

The neurobiological relationship between music, memory and learning is highly correlated. The structural components of music are thought to facilitate memory 'chunking'. Chunking is the organisational process by which information is broken down into manageable and salient subdivisions and is neurally encoded. Melodic, harmonic and rhythmic musical forms are such that music may function as a memory template for learning and memorisation (Thaut, 2005). In this way, it can be understood how music can remain so emotionally resonant and personally salient: music connects with thought and memory. Further information about music and memory is contained in Section 4.4.1.

Having assessed the psychological substrates for the emotional and personal salience of music, it is clearly evident how music can be dynamic in a clinical setting. Through cognitive-coping and attentional distraction, music can be psychologically active. This

can function to improve mood, reduce anxiety (Brotons and Marti, 2003; Browning, 2000; Chlan et al., 2000; Cooke et al., 2005; Lee et al., 2005b; MacDonald et al., 2003) and depression levels (Evans, 2002; Hsu and Lai, 2004; Lai, 1999; Maratos and Gold, 2005; Siedlecki, 2005). The appropriateness of a music listening intervention is preference-dependent and this is of fundamental importance to experimental research in this area. Providing patients with choice and involvement in their treatment can improve locus of control (Even, 1997; Hirokawa, 2004) and promote familiarity and personal relevance in an impersonal situation.

### **3.4 Music and the Sociological Dimension**

Research into the social psychology of music has been extensive (see Hargreaves and North, 1997, for example). Despite this, little has encompassed the medical sphere in its discussions of sociology and music. This section will focus on the key concept of music listening as sociological ‘activity’ and then will address the rationale for including music in clinical practice.

#### **3.4.1 Music and Activity**

The principal focus of the sociological role of music in a clinical setting is through the concept of interest or ‘activity’. ‘Activity’ denotes a state of being active and engaged in any specific behaviour, be it physical or psychological. The use of ‘activity’ has become a fundament of the cognitive-behavioural approach, as through activity the patient develops interests outside the realm of their pain experience (Kingdon et al., 1998; Liversidge, 2004). The attentionally demanding nature of pain (see page 13) means that pain can quickly become an all-encompassing, all-absorbing focus of attention. Beyond this, it becomes difficult to function normally or to engage in social activity. By engaging with some form of ‘activity’, pain subsequently becomes peripheral, competing for attention rather than representing the focal point of the pain sufferers’ daily life (Caudill-Slosberg, 2002).

The use of quasi-preferred or preferred music can be an important facilitator of activity. By selecting their own music and then subsequently engaging with that music, patients are forced to get involved in activity beyond the realms of their pain. The exercise of choosing, considering and investigating music develops patients’ interests in treatment modalities and also has the potential to promote leisure interests outside

the sphere of pain-induced restrictions (Argyle, 2003; Brotons and Marti, 2003). To select music for the purpose of listening, patients must explore, choose, purchase or tune in to their desired music for the purposes of accessing music which is relevant to their particular taste and context. In this way, music listening can become an interest and may forge positive-identification with a fan-base (Even, 1997; Hargreaves and North, 1997), which may later result in behaviourally-active musical activity via concert attendance, fan-base websites, blogs or group involvement. Additionally, for those participants for whom music represents a performance medium, partaking in regular music listening can foster a desire for learning, re-learning or playing a musical instrument in a solo or group context.

The success of music at inducing ‘activity’ is to some degree dependent on the person. In a research situation, music listening cannot activate fan-base membership for example, but it provides an opportunity for subsequent activity for the patient that is music-related. Music listening is an activity in and of itself and therefore in essence provides patients with the opportunity to engage with activity external to their pain. Whether the participant chooses to take this opportunity depends on the personality and the deliberate effort of the subject in question. If they opt to interact with the stimulus and focus their attention upon the intervention, then physiological and psychological results may be apparent. When the research period has ceased, outwith the research environment, there is opportunity for furthering the interventional activity if the participant so desires. Patients can replicate the intervention at home and this can provide opportunities for musical choice and activity. This is a prime reason why music used in medical research should be commercially available—the option should be provided for participants to continue with their intervention in a familial setting. Ultimately, through musical activity, social isolation can be limited or diminished and a focus on pain could be supplanted by attention given to music and all of the active social domains that ‘music’ incorporates.

### **3.4.2 Music and Clinical Practice**

The use of music is extremely relevant for inclusion in a hospital setting. Clinical practice provides little available time for the use of additional adjunctive treatments. Clinicians are required to effectively execute their job, performing daily to high standards under situations of high stress and under great demand. Doctors, nurses or other health practitioners are not available for taking any additional task load. Music lis-

tening is an intervention which is sensitive to this and appropriate. Beyond optional education of staff about the potential benefits of music listening for patients, staff are not required to deal with the application of the intervention in any way. Music listening is patient-centred and patient-administered. Patients can select their own music, either from a quasi-preferred library, or from their own collections. They can listen to this music on their own personal music players without interrupting others in any way, or jeopardising their own standard of medical care. Music can be used when directed (for example in the context of a research study), or when wanted, day or night. Music can be played as often or as rarely as desired, for as much or as little time as the listener wishes. The flexibility of music as an intervention is unusual and as such, is highly relevant.

Music as a stimulus is non-invasive and has no side-effects. Research has shown that even poorly received or negatively valenced music cannot be detrimental to pain or well-being (Kenntner-Mabiala et al., 2007; Roy et al., 2008). Positively received music, by contrast, can be active biologically, psychologically and sociologically. In this way it can influence patients multi-dimensionally and music can only result in either none or beneficial effects. Where music has the potential to improve health status through regulating vital signs or stabilising psychological state, this can only be advantageous for the hospital. If music reduces intra- and post-operative analgesic requirements, or lowers requests for rescue medication, then this has financial benefits for the healthcare trust (see Nilsson et al., 2001, 2003). When music improves a patients' sense of agency in treatment and increases their satisfaction with their hospital stay, then it is promoting positive evaluations of hospital care (see Good et al., 2001; McCaffrey and Good, 2000, for discussion). This is profitable for the patients in question and for the hospital trusts and/or clinicians involved. An adjunctive music listening intervention is viable to assist in patient care in conjunction with pharmacological interventions and as part of a multi-modal pain management programme. Overall, music is freely and readily available to everyone for relatively limited financial outlays. The use of music as an adjunctive treatment and as part of a medical 'kit' (Pellino et al., 2005), is relevant, viable and appropriate.



Author(s)	Origin/Setting	Aim/Research Question	Design/Sample	Instrument(s)	Intervention(s)	Findings
Carroll, D. & Seers, K. (1998)	UK: Chronic Cancer Pain	To assess whether music is effective in reducing chronic cancer pain	RCT: 40 chronic cancer pain sufferers	MPQ. Pain intensity 100mm VAS. Pre- and post-assessment	Music Group: 30mins of quasi-preferred Relaxing Music via 10 instrumental musical tapes Control Group: dimmed lights and rest	Music induced lower scores on all MPQ dimensions except PPI. Music reduced pain intensity for Music Group.
Chafin, S. et al (2004)	USA: Laboratory-induced stress	To see whether listening to music would reduce post-stress blood pressure elevations	Laboratory-based experimental design: 75 healthy participants	Stressful Mental Arithmetic Task. BP, HR: both continuously monitored. Anxiety 7pt Likert Scale. Qualitative data. STAI Pre- and post-test	Non-preferred musical choice of Classical, jazz, pop in recovery period. Or choice of music from selection or silent resting control.	Significant effect of music condition: music returned Systolic BP closer to baseline than control. Jazz was less familiar. No difference in induced relaxation. No diff. on STAI
Good, M. et al (1999)	USA: Clinical post-operative acute pain	To investigate the effects of music, relaxation and their combination after abdominal surgery	RCT: 500 major abdominal surgery patients	Sensation and distress of pain VAS at ambulation and rest. PCA, HR, RR, BP. Pre & post daily for 48hrs.	Music Group: 60 minutes of sedative music, quasi-preferred selection: 5 types (classical orchestral, popular piano, slow jazz, synthesiser, harp) Relaxation: jaw relaxation. Combination or Standard Care.	Music and relaxation showed less pain except on ambulation. Combination was significantly better at both rest and ambulation. Combination group showed less pain than music/relaxation.

Author(s)	Origin/Setting	Aim/Research Question	Design/Sample	Instrument(s)	Intervention(s)	Findings
Good, M. et al (2002)	USA: Clinical post-operative acute pain	To research the effect of relaxation, music and their combination after gynaecological surgery	RCT: 311 gynaecological surgery patients	Sensation and distress of pain VAS at ambulation and rest. PCA, HR, RR, BP. Sleep quality categorical scale. Pre & post daily for 48hrs.	As above, intervention undertaken throughout ambulation, rest and recovery.	Poor sleep preceded painful day. Intervention groups had less sensation and distress of pain. Up to 29% reduction due to relaxation and music independent interventions.
Good, M. et al (2005)	USA: Clinical post-operative acute pain	To examine the effects of relaxation, music and their combination after intestinal surgery	RCT: 167 intestinal surgery patients	Sensation and distress of pain VAS at ambulation and rest. PCA, HR, RR, BP. Sleep quality categorical scale. Pre & post daily for 48 hrs	As above, but control group undertook conversation with the experimenter. Intervention used throughout ambulation, rest and recovery.	Combination intervention resulted in less pain on Day 1 and Day 2 at rest only. 70% of patients were asleep at the end of their tests. No change to vitals or PCA.
Hekmat, H. M. & Hertel, J. B. (2003)	USA: Laboratory-induced pain	To investigate if music interventions can improve pain tolerance and see if preference for the stimulus attenuates the pain experience	Experimental Design: 80 healthy participants	CPT. 100mm VAS of liking for music. 1.1pt NRS of pain intensity. Pain tolerance (minutes, max 6mins). Pre-, intra- & post-test.	Quasi-preferred music: most and least preferred of five electric organ pieces. Experimenter present and experimenter absent trials. Silent baseline.	Quasi-preferred music most liked increased pain tolerance. Non-preferred and control pain tolerance were similar. Music assisted more than no music

Author(s)	Origin/Setting	Aim/Research Question	Design/Sample	Instrument(s)	Intervention(s)	Findings
Ikonomidou et al (2004)	Sweden: Clinical post-operative acute pain	To see whether relaxation music would influence pain, nausea, well-being and vital signs in women undergoing laparoscopic gynaecological surgery	RCT: 60 female laparoscopic gynaecological surgery patients	100mm VAS pain 100mm VAS nausea. 100mm VAS anxiety. HR, BP, RR. Pre-, intra- and post-test	Peaceful panpipe music versus no music. 30 minutes before surgery and 30 minutes after surgery	Music group: highly significant reduction in pre-op RR, but no post-op change. HR decreased post-op for both groups. BP decreased post-op for music. No difference between groups for pain scores. Music improved wellbeing and reduced post-op rescue medication.
Kenntner-Mabiala, R. et al (2007)	Germany: Laboratory-induced pain	To separately investigate the effects of mode and tempo in classical music on pain perception and gender	Mixed factorial experimental design: 38 non-musician healthy participants	Thermal noxious stimuli. Unpleasantness and intensity of pain 0-10 Likert scale. Temperature rating of stimuli VAS. ECG, RR. Arousal, mood and valence of music. Pre and post each example.	Non-preferred music. 24 80sec extracts of piano classical sonata movements. Tempo: Slow, medium or fast. Mode: major/minor	No difference in valence ratings. Arousal was stronger for females than males. Happiness was higher for major than minor modes. Higher HR and RR during fast pieces. Higher pain intensity and unpleasantness for females during fast music.

Author(s)	Origin/Setting	Aim/Research Question	Design/Sample	Instrument(s)	Intervention(s)	Findings
Khalfá, S. et al (2003)	France: Laboratory-induced stress	To investigate whether music listening reduced induced stress in males	Experimental design: 24 healthy male university students	Trier Social Stress Test. Salivary Cortisol concentration. Pre-intervention and post-test periodically for 45mins.	Silence or non-preferred relaxing music for 45mins in the recovery phase after stress test. 10 examples of relaxing music by Enya, Vongels or Yanni.	Both groups responded to stress. Music reduced cortisol in the first part of the recovery phase, when the control group's cortisol concentration went up.
Lai, Y. (1999)	Taiwan: In-patient mental health (depression)	To assess the impact of music on major depression, mood and vital signs	RCT: 30 female major depression sufferers	Qualitative data. HR, RR, BP. Mood adjective questions. Pre- and post-intervention.	'Pink noise' versus quasi-preferred music for 30 minutes. 1 of 4 examples: classical music, new age music, Chinese music or oriental new age music	HR, BP and RR decreases were greater in music group. Control group showed no differences in RR/BP but slight drop in HR. Increase in tranquil mood state in both groups.
Lee, D. et al (2004)	Hong Kong: pre-operative day-surgery clinical stress	To investigate the effect of music on pre-procedure anxiety in day patients	Quasi-experimental design with non-random assignment: 113 day procedure patients	Chinese STAI. BP, HR and RR. Pre- and post-test.	20-40mins of qualitatively preferred music versus rest: choice of 10 extracts, all either western-style easy listening or Chinese pop.	Music group showed lower post-test anxiety than controls. No difference in physiological parameters.

Author(s)	Origin/Setting	Aim/Research Question	Design/Sample	Instrument(s)	Intervention(s)	Findings
Lee, O. et al (2005)	Hong Kong: Clinical ICU acute stress	To see whether the use of anxiolytic music reduces anxiety and vital signs in mechanically ventilated patients	RCT: 64 mechanical ventilator-dependent patients	Chinese STAI. BP, HR and RR. Patient behaviour and patient satisfaction. Pre- and post-intervention.	30mins of quasi-preferred music or rest. Choice of three genres: Buddhist or Christian religious music, Western classical music, natural sounds.	HR, RR and BP decreased rapidly in music than non-music participants. Greater increase in comfortable behaviour in music group. No difference on C-STAI.
MacDonald, R. et al (2003)	Scotland: post-operative surgical acute pain	To investigate the effects of music listening within the hospital environment.	RCT: 2 studies. Study 1: 40 foot surgery patients. Study 2: 58 female hysterectomy surgery patients	PCA. MPQ. VAS pain intensity at rest and movement. STAI. Measures taken at regular intervals for 72 hours.	Standard care vs. preferred music (patient selected CD from own collection) for as long as possible in the post-operative period.	Study 1: music induced more anxiety reduction than no music. Study 2: significant reduction in anxiety on STAI, but no difference between groups. No change in pain states
McCaffrey, R. & Good, M. (2000)	USA: post-operative surgical acute pain	To learn of the broader effect of music by using a phenomenological approach	Phenomenological case-study design	Daily interview. Conversation. Behavioural observation (facial expressions and bodily gestures) for 48 hours post-operatively	20 minutes of qualitatively preferred music used at any time. Choice of 20 musical tapes ranging from classical to country & western. When and what music as desired.	Music provided comfort in a disconcerting condition. Music created familiarity in a strange environment. Music distracted from pain in the post-op period.



Author(s)	Origin/Setting	Aim/Research Question	Design/Sample	Instrument(s)	Intervention(s)	Findings
McCaffrey, R. & Freeman, E. (2003)	USA: Chronic osteoarthritis pain. Non-clinical setting.	To investigate the use of music listening for attenuating pain perception for elderly pain sufferers	Longitudinal experimental design: 66 older participants with chronic pain (2:1 women to men)	SFMPO on Day 0, day 7 and Day 14 Daily and weekly pre- and post-test.	20 minutes of rest or non-preferred classical music (60-80bpm) used daily in the mornings for two weeks	Significant difference between experimental and control groups in pre- to post-test pain reduction. Cumulative decrease across weeks of testing for music group but not control group.
Miluk-Kolasa, B. et al (1996)	Poland: non-orthopaedic pre-surgical stress	To evaluate the effects of music on selected physiological responses of patients waiting for non-orthopaedic surgery	Experimental design: 100 pre-surgical patients	HR, BP. Stroke volume and cardiac output. Skin temperature and blood glucose levels. Pre-test and every 20 mins after for 1hr.	Rest period or quasi-preferred music used for one hour before surgery.	The music group showed a quicker return to baseline for all measures.
Mitchell, L. et al (2006)	Scotland: laboratory-induced pain	To assess the efficacy of preferred music in comparison to humour or mental arithmetic for laboratory-induced pain	Experimental design: 44 healthy university students. Counterbalanced trial.	CPT. Immersion time for pain tolerance. VAS for pain intensity. VAS of perceived control. Pain Rating Index from the MPQ.	Preferred music (participant-selected) vs. audiotaped humour (Billy Connolly) or Auditory Serial Addition Task. All against baseline silent condition.	Music resulted in greater pain tolerance. Humour not significantly different from music or maths. Music provided a greater distraction and larger levels of perceived control.

Author(s)	Origin/Setting	Aim/Research Question	Design/Sample	Instrument(s)	Intervention(s)	Findings
Nilsson, U. et al (2001)	Sweden: Clinical intra-operative acute pain	To see whether the intra-operative use of music and therapeutic suggestions effectively reduces post-operative pain, nausea and analgesia	RCT: 90 female abdominal hysterectomy patients	Pain intensity 100mm VAS taken every hour for 24 hours and then every three hours until no pain. Time to mobilisation. Fatigue, vomiting, well-being.	(1) Headphones with operating room sound, (2) non-preferred relaxing and calming music accompanied by sea sounds, (3) therapeutic suggestions or (4) music and therapeutic suggestions. Played continually during surgery.	Music and combination groups showed less fatigue than controls. Music groups mobilised earlier. Music only reduced pain on Day 1 compared to controls. No difference in nausea, well-being or length of stay.
Nilsson, U. et al (2003)	Sweden: Day surgery acute pain intra- and post-operatively	To evaluate the most appropriate timing for music, either during surgery or during the recovery period following surgery.	RCT: 151 day-case varicose vein or inguinal hernia repair patients	11pt Anxiety VAS and pain intensity VAS, nausea and fatigue NRS taken every 30mins for 2 hours. PCA morphine. Paracetamol usage. Sleep quality VAS	Non-preferred synthesised new age music versus no music on a blank cd. Intra-op until wound dressing or from arrival at PACU for 1 hour.	Intra- and post-operative patients reported lower pain at one and two hours post-op than controls. Post-op music group required less morphine after one hour in the PACU than intra-op music or control. No change in Anxiety.



Author(s)	Origin/Setting	Aim/Research Question	Design/Sample	Instrument(s)	Intervention(s)	Findings
Phumdoung, S. & Good, M. (2003)	Thailand: Clinical acute labour pain	To explore whether music would reduce sensory and distress ratings of pain during labour	RCT: 144 women experiencing labour pain	Hourly 100mm VAS for sensory and affective pain. Feedback interview detailing liking, helpfulness and tiredness of music.	Quasi-preferred music or no music heard for the first three hours of the active phase of labour. 1 of 5 types of sedative music: classical orchestral, popular piano, slow jazz, synthesiser and harp.	Control group had greater pain post-test. Pre-test sensation and distress of pain correlated with post-test sensation and distress. Less sensation and distress of pain for the music group. Music delayed increase in distress until 2 <sup>nd</sup> hour. Heterogeneous effect.
Roy, M. et al (2008)	Canada: laboratory-induced pain	To assess whether pleasant excerpts would reduce pain whereas unpleasant ones would increase it	Experimental design: 18 healthy university students	Noxious thermal stimuli. 100pt NRS rating of thermal stimuli. POMS. 100pt NRS of unpleasantness and intensity of pain Valence/arousal of induced emotions Pre-, intra- and post-test ratings	Silence or non-preferred music that was either pleasant or unpleasant. Total duration of test: 15mins.	Pleasant and unpleasant music were arousing. Anger, anxiety, intensity and unpleasantness of pain lower after pleasant music. No pain-enhancing effect of unpleasant music. Analgesia most effective in conjunction with pleasant emotions.

Author(s)	Origin/Setting	Aims/Research Question	Design/Sample	Instrument(s)	Intervention(s)	Findings
Schneider, N. et al (2001)	Germany: Clinical stress	To assess whether music can influence the stress reaction of patients undergoing cerebral angiogram	RCT: 30 patients given a cerebral angiogram	STAI. Plasma cortisol and catecholamines BP and HR. Pre- and post-test.	Standard care or quasi-preferred music for a mean 74mins listening. 1 of 9 tapes: International pop, german pop, oldies, meditation, rock, techno, instrumental, classical or traditional music	93.3% found music helped relaxation. 71.4% this was due to distraction. Music limited the rise of cortisol compared to silence. SBP fell in music group. Anxious patients improved most.
Voss, J. et al (2004)	USA: Clinical post-operative acute pain	To evaluate the use of sedative music to reduce anxiety and pain in chair rest following heart surgery	RCT: 62 patients in the ICU following open heart surgery	Anxiety, pain sensation and pain distress VASs. Qualitative feedback. Pre- and post-test.	Chair rest or 30mins quasi-preferred sedative music. 1 of 6 choices: New age synthesiser, popular piano, classical orchestra, harp, slow jazz or Indian flute music.	Music group were 72% less anxious than controls. Music group had 60% less pain distress and 57% less pain sensation than those with scheduled rest. Music as a pleasant distraction.
Wang, S. et al (2002)	USA: pre-procedural anxiety before outpatient surgery	To investigate the effectiveness of music for decreasing pre-operative anxiety.	RCT: 93 pre-surgical patients in the waiting area	STAI HR, BP, electrodermal activity. Serum cortisol, adrenaline, noradrenaline. Pre-, intra- and post-test.	Standard care or Preferred music (patient selected from own collection) for 30mins.	Music group were less anxious. Anxiety in music group decreased 16% between pre- and post-test. No difference on other measures.

Table 3.1: Key music, pain and stress research studies

# Chapter 4

## Musical Categorisation

### 4.1 Introduction to Musical Categorisation

Music has long been investigated from musicological, biological, sociological and philosophical standpoints. It is perhaps in its ‘interdisciplinarity’ that music may best be appreciated. It is beyond the scope of this thesis to investigate every field of research encompassing ‘music’; indeed, this is not the aim. It is, however, important to clarify where the most salient questions lie; essentially those issues which specifically pertain to clinical methodology. In clinical research as a result of the demand for clarity and transparency in the design and methodology of research, the decisions made concerning methodology are extraordinarily important. Where music is to be integrated into medical care, it is often viewed as just ‘music’—a simplistic, one-dimensional, homogeneous entity. Clinical research typically compares ‘music’ with standard care (for examples see Good et al., 2002; Khalfa et al., 2003). Whilst this is a clean and well-defined structure for experimental research, it is perhaps limited by its ability only to demonstrate the efficacy of one particular ‘music’ on a single patient population. Consistent research in this vein may ultimately generate a consensus in research findings over a period of years: however, is this methodology appropriate? Just as a wealth of research is undertaken into different medical treatments, if music is to be used in a clinical setting a similar depth of research could be applied to investigate music itself. If music is to be incorporated in a clinical setting, then necessarily the music must be appropriate for use in this context. Ultimately, judgements must be made about ‘what’ music is to be used. There must be answers to the questions surrounding ‘why’, ‘how’ and indeed ‘what’ music is useful as an intervention. To maintain a one-dimensional, generic overview of the broad effects of ‘music’ may impoverish and

neglect the unique individuality and diversity of ‘music’ in all its wholeness (Nattiez, 1990).

It is undoubtedly difficult, upon hearing music, to mistake music for anything else. Be it “an artistic form of auditory communication, incorporating instrumental or vocal tones in a structured or continuous manner” (Wordnet, 2006), or more simply “any agreeable (pleasing and harmonious) sounds” (Wordnet, 2006), ‘music’ is still clearly identifiable and recognisable as such. Yet what makes music music? As commented about PhD research by pianist and composer Vijay Iyer at the Berkeley Center for New Music and Audio Technologies:

“A definition of music would seem to be necessary, but I will not attempt such a manoeuvre. However, it is enlightening to discuss problems one might encounter in constructing such a definition” (Iyer, 1998, p.37).

It is clear that a multiplicity of factors come into play when attempting to depict the totality of ‘music’. Perceiving music solely as ‘organised sound’ questions music which is composed around/uses the sounds of nature, for example. Additionally, it is problematised by music using compositional and/or performance techniques which deliberately eschew organisation (e.g. through improvisation, or the incidental dissonance and asymmetry of atonality). Alternatively, viewing music definitively as the opposite of ‘organised sound’; instead a pseudo-random collection of tones, pitches and sounds, neglects the richness of the Western classical tradition and the carefully designed and weighted masterpieces composed through a lifetime of work. It is evident then, that there must be some discussion of fundamental constructs and factors which contribute towards the (potentially indefinable) concept of ‘music’. Similarly, there must be analysis of those factors which mediate or impinge upon the public perception of and response to ‘music’.

Clinical research prioritises the importance of minimising any confounding variables in experimental work. Empirical research must therefore be clearly delineated with well-defined groups, validated outcome measures, reliable methodologies and of sufficient power to generate both statistically significant and clinically meaningful results (see ANZCA, 2005). Without defined groupings and a logical rationale for selecting the experimental treatment methods and methodologies, replicability of research becomes difficult and ultimately the contribution of such research to the field is limited. The balance then, is in maintaining the ecological validity of research; clarity and definition acting as a foil to originality, individual variables, groupings, methodologies and protocols allowing sufficient freedom for the findings and data to take on

their own direction.

An issue fundamental to clinical research is that of the ‘categorisation’ of music. Categorisation refers to the basic cognitive process of distributing and arranging things into classes or categories of the same type. In order to find out whether a treatment is effective or not in clinical research, separate groups or treatments must be compared against each other. Using music as a treatment intervention in this context necessarily invites some form of ‘categorisation’, be it by genre, composer, preference or compositional constructs, for example. With a desire to maintain an equilibrium between reducing potential biases and challenging any preconceptions, categorisation becomes extremely important for musicological/medical research. Clinical research (as outlined in Chapter 3) has suggested that music can potentially reduce pain, but it has rarely looked at what music, or what within the music, triggers this effect. It is important therefore to manipulate some intra-musical features in order to fully comprehend the function of music in analgesia. Categorisation decisions must therefore be taken to determine what music is to be used in the research. Categorisation can be generic or highly specific. Outlining an appropriate rationale behind the categorisation of music for clinical studies may facilitate greater cohesion in the research domain. Categorisation of music is involved in every study involving musical sound, whether by genre or grammar, composer or construction, preference or personal perception.

Musicological and psychological research, perhaps without conscious apprehension of the fact, requires categorisation. The variability in the categorisation procedures and methodologies of musicological and psychological research, is seemingly in conflict with the established protocols for clinical research. Such research uses a plethora of different grouping constraints or constructs, and there has been little discussion of the appropriateness of these categorisations (see only the theoretical discussions of Lerdahl and Jackendoff, 1983; Nattiez, 1990). It is important to consider the reasons for, and requisites of, each category, and the rationale behind the *method* of categorisation, in order to successfully determine reliable and valid groupings. Categorisation, principally for the purpose of experimental research, is therefore prioritised as a central tenet of clinical, psychological and musicological research.

It is tempting to utilise a random selection of musical samples in research, without considering the theoretical rationale behind the choices. This is problematised when music is intended for use in the course of a rigorous scientific investigation. Though ecological validity in research is important, necessitating research based in the ‘real world’, similarly important is research which manipulates single variables of interest.

To this end, there should be some discretionary control of any factors which may positively or negatively impinge upon any clinical findings. Music should not be exempted (without reason) from this concept of control, and it is therefore important that any musical choices in research are subject to some careful methodological justification. For the purposes of this chapter on musical categorisation, a literature search was undertaken on medline, pubmed, psychinfo and Repertoire Internationale de Littérature de Musicale (RILM), using the terms music preference, music categorisation, taste cultures, musical taste and musical style. The resulting key research studies are detailed in this section.

## 4.2 Constructs to Consider

Appropriate categorisation of music may be the goal, but care must be taken to balance this desire against over-reification of the variable. Reification asserts that the only constructs of importance are those that can be experimentally controlled and measured (Sloboda, 2002). Control is necessary for hypothesis testing, but only when the control is undertaken in conscious awareness of the fullest complexity of the phenomenon (Sloboda, 2002). Therefore the goal is categorisation, but the context is ecological validity: the use of a chosen method which resembles actual music in significant ways. The objective is to find one or more positively divisive construct(s) that enable the researcher to select meaningful musical samples for clinical research. These samples must represent music in all its fullness, and provide a working library of extracts and examples. As the canon of recorded music is never static and is continually added to, the method of categorisation must be rapidly accessible and applicable to new music in order to cope with the exponentially increasing output of the music industry. Potentially, categorisation may at some point in the future be automatised, though this likely will never compete with the ear in its power of discernment or appreciation of the intricacies of musical extracts. Categorisation constructs must be cross-cultural, in order to accurately reflect the wealth of world musics as well as western musics. They must also be relevant both to ‘popular’ and ‘classical’ music and any genres between or outwith these poles.

To consider possible categorisation constructs, there are multiple options, each with advantages and disadvantages. The most relevant possibilities may be conceptualised by and divided into two broad groups:

1. **Genre Specification**

Factors of genre or type; musical genre, type of music, era, date of composition, artist and culture.

## 2. **Compositional Construction**

Compositional factors that divide between musical examples; tonality, consonance and dissonance, rhythm and harmony, for example.

For the purposes of this research study, it was determined that the field of music medicine could gain from some investigation into intra-musical features. Thus the analysis of genre specification and compositional construction contained in this chapter was an active attempt to select the most appropriate method of categorisation. The chosen method could subsequently be applied to the clinical research, dictating patient allocation to musical groups and the types of music used for the purposes of the intervention. Genre specification will be investigated first, and then the medical research studies which have used genre will be outlined. Following this, possible methods of categorisation according to compositional construction will be discussed and subsequently related to previous research.

## 4.3 **Genre Specification**

Van Eijck (2001) viewed genre as more or less representative of a specific social milieu. Through experiencing and living in these milieus, people get to know and appreciate those musics (Van Eijck, 2001). Genres are specific by-products of musical cultures and there is a broad spectrum of cultural musical products available (Frith, 1996). It is common to find that music has been categorised according to the prevailing themes in contemporary music, with classifications changing according to the terms and descriptors currently in vogue (see Litle and Zuckerman, 1986; Smith, 1994, for examples). Whilst this methodology may be justifiable in light of its potential to represent a contemporaneous sociological context, practically it is potentially too complex for use in clinical research. If genre were to be used in music medicine research, it would be important to assess all possible genres and to compare between genres to demonstrate the most efficacious music for analgesic gain. Whilst this may seem possible and indeed plausible at first glance, the reality is very different. Genre does not just depict classical versus popular music. So-called 'classical' music incorporates a dramatic variety of sub-divisions: medieval music, baroque, classical, romantic, minimalist, modernist and avant-garde for example. Each era of classical music is different from the next

and comparison between romantic music and minimalist music, for example, is very difficult. Where some classical epochs have built upon the developments made in previous years, others have deliberately deconstructed and eschewed their predecessors, particularly in twelve-tone and minimalist approaches, for example. Similarly, within classical music there are discrepancies within the musical format: opera, chamber, choral or orchestral for example. If this is the level of imperspicuity within classical music, then it is difficult to argue for its inclusion in music medicine research as a singular genre.

Popular music fares no better. Popular music is not homogeneous, but is a conglomeration of splinter musical approaches which together make up the perceived mainstream and deviants of popular music. Lewis (1995) found that college students in Pennsylvania could cite no less than twenty-six types of preferred popular music. Rock, soul, funk, britpop, hiphop, R'n'B, rap, heavy metal, goth, easy listening and top 40 to give but a few subdivisions. Likewise, 'Jazz' includes trad jazz, blues, acid jazz, latin jazz, bebop, modern jazz, big band and more. If music medicine were to truly attempt to use genre as a method of categorisation, the genre choices would have to reflect the genuine proliferation of different musics that make up what can so easily be seen as single genres. Just as romantic music and atonal music are musically and conceptually different, the sound of gothic music is not easily comparable to easy listening, nor is blues to latin jazz. Genres may 'borrow' and appropriate material from each other, but they are intrinsically difficult to compare. The multiplicity of genres represents the passing of time, advances in music technology, preference differences of different birth cohorts and changes in compositional techniques. To use genre in medical research is a common approach, but one which is problematised in light of a desire to maintain verisimilitude and avoid reification in the choice of variables used in experimental research.

Having viewed the complexity of categorisation by genre, it is crucial to consider musicology research which has used genre categorisation and to investigate the homogeneity and disparity within this research. The study by Litle and Zuckerman (1986) stands as one of the most inclusive studies into existing genres (see Table 4.1 for a listing of genres). The research was deliberately designed to avoid the narrow genre-specific approach that music research sometimes utilised. US record companies were contacted in order to find out what divisions were used within the industry. The results created ten broad categorical genres of music which were subdivided into sixty further within-category genres. The results of the study outlined the genres in relation



to contemporary music of the time (see Table 4.1). This study clearly depicts the problems that arise when attempting to categorise by genre for music medicine research. Assessing the role of all genres of the Music Preference Scale (MPS) for pain management would be an impossible task. Even musicological studies which have reduced the number of genres that they describe still present a large number of groups required to assess all genres in experimental research.

Table 4.1: Genres of music included in the Music Preference Scale (Litle and Zuckerman, 1986)

<b>Musical Category</b>	<b>Genre Divisions</b>
<b>Rock</b>	Rock music in general
	Rock and roll (Buddy Holly)
	Acid rock (Jimmy Hendrix)
	Heavy metal (Iron Butterfly, Led Zepellin)
	Surfer (Beach Boys)
	Jazz-rock (Chicago)
	Pop rock (Moody Blues, Queen)
	Punk rock (Sid Viscious)
	New Wave (Cars, Blondie)
	Mainstream (Styx, Genesis)
<b>Classical</b>	Classical music in general
	Baroque (Bach)
	Classical (Mozart, Beethoven)
	Romantic (Tchaikovsky, Schubert, Schumann)
	Impressionistic (Debussy)
	Neoclassical (Stravinsky, Chopin)
	Contemporary (Bernstein, Ives)
<b>Electronic</b>	Electronic music in general
	Classical (Karl Stockhausen, Walter Carlos, Tomita)
	Modern (Jean-Michel Jarre, Mike Oldfield)
<b>Jazz</b>	Jazz in general
	Dixieland (Preservation Hall Jazz Band)
	Big band/Swing (Glenn Miller, Duke Ellington)
	Bebop (Charlie Parker)
	Progressive jazz (Miles Davis, Herbie Hancock)
	West coast style (Buddy Rich, Don Ellis)
	East coast style (Urbie Green, Grover Washington)
	Big band jazz/pop (Maynard Ferguson, Lou Rawls)
<b>Soul/rhythm &amp; blues</b>	Soul or rhythm & blues in general
	Rhythm & blues (Manhattans, James Brown)
	Soul-rock (Stevie Wonder, Earth, Wind & Fire)
	Gospel (Aretha Franklin)
	Modern style (Teddy Pendergrass, The Jacksons, Diana Ross)
	Soul-jazz style (Pointer Sisters)
<b>Popular</b>	Disco music in general (Donna Summer, Fantasy, Shalamar, Lipps Inc)
	Top 40 vocal music (Abba, Barry Manilow, Bee Gees, Barbra Streisand)
	Top 40 jazz oriented (Steely Dan, The Doobie Bros)
	Easy listening music in general

	Easy listening—vocal (Perry Como, Frank Sinatra)
	Easy listening—instrumental (1001 Strings)
<b>Country &amp; Western</b>	Country & Western music in general
	Classic country style (Dolly Parton, Anne Murray, Hank Williams Jr)
	Modern country style (Kenny Rogers, Barbara Mandrell)
	Gospel Style (The Oak Ridge Boys, The Statler Bros)
	Country-folk style (Emmylou Harris, Hoyt Axton)
<b>Folk/ethnic</b>	Folk or ethnic music in general
	American folk music (Judy Collins, The Limeliters, Doc Watson)
	Bluegrass (The Carter Family, Bill Monroe and the Bluegrass Boys)
	Folk music from other cultures (Vicki Carr)
<b>Religious</b>	Religious music in general
	Gospel (Andre Crouch, Gospel Quartet)
	Hymns
	Modern (Evie, Bob Dylan)
<b>Soundtracks</b>	Broadway, movie and TV soundtrack music in general
	Broadway musicals (Oklahoma, A Chorus Line, Beatlemania)
	Movie musicals and soundtracks (Starwars)
	Television show soundtracks and themes

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Research by Smith (1994) is one of the few research studies that has attempted to respond to the challenge of multiplicitous genres by collapsing these into broad-genre factors. Working with generational birth cohorts, Smith identified eighteen different genres of music that were salient to the population at the time of testing: big band/swing, bluegrass, country and western, blues or R'n'B, Broadway musicals/show tunes, classical music: symphony or chamber, folk music, gospel music, jazz, Latin/mariachi/salsa, mood music/easy listening, new age/space music, opera, rap music, reggae, contemporary pop/rock, oldies rock and heavy metal. From these eighteen genres, five factors emerged that depicted a higher categorical coalescing between genres:

1. **Haute and pop standards:** Musical styles that enjoyed their peak popularity prior to 1940
2. **New styles:** All genres from 1970
3. **Minority-oriented urban music:** Centres around jazz and blues with Latin and reggae also related
4. **Country:** American or American-derivative country styles

### 5. **Rock and Roll:** Rock styles from the past and present

Genres and factors which were most popular were those which pertained to the era in which the participant was born. This represents the fact that popularity is greatest when the musical genre first emerges and achieves its initial following. Genre popularity is related to an identification with the progressive youth culture of the time (Smith, 1994). This popularity then declines, though rarely disappears, and ultimately is replaced by a new genre which may or may not be related to the previous musics.

In the same vein, Lewis (1995) classified rock, country, rap, alternative, classical, reggae, heavy metal, top 40, world and easy listening as dependent upon their orientation to establishment culture. The younger the musical listener, the more likely they are to be a member of a reactive musical taste culture, and the older listener tends towards convergent taste cultures (Lewis, 1995). The study found that musical genres are thought to be:

1. **Culturally reactive:** rap, heavy metal
2. **Culturally convergent:** country or classical
3. **Culturally divergent:** alternative or reggae

Whilst these factor-analytical studies are useful and provide an insight into the functions of genre within a specific taste culture, or ways in which genres can be broken down, they still represent quite a significant number of groups in order to test the factors in medical research. Additionally, the factorial subdivisions are valid but not easily representable to the general public. A patient involved in a music medicine research study would struggle, on returning home post-surgery, to go and buy 'culturally divergent music'. The concepts are useful for academical research, but are not applicable to day-to-day musical selection by ordinary (non-academic) music listeners. The division by Frith (1990) of music into art music, popular music or folk music is somewhat easier to comprehend, but what music belongs in which category is highly subjective and as such is dependent on the prevailing opinion and musical experience of the listener. For some, Tubular Bells by Mike Oldfield, for example, may represent unfamiliar minimalist art music using patterns and cells of musical notes in repetition. For others, particularly those with more formal musical education, Oldfield might be construed as popular music.

### 4.3.1 Genre Specification in Music Medicine

To look then at the role of genre in music medicine research (see Table 3.1). Genre inclusion is generally dependent upon the preference methodology utilised in the study: non-preferred, quasi-preferred or preferred (see Section 3.3.3). Those studies which have applied non-preferred extracts as a music listening intervention have typically used classical or new age musics. Patients have been given classical music which has most often utilised classical instrumental sonatas (Kenntner-Mabiala et al., 2007; McCaffrey and Freeman, 2003). Patients provided with new age music have listened to synthesised music (Carroll and Seers, 1998; Hekmat and Hertel, 2003; Nilsson et al., 2003), panpipe music (Ikonomidou et al., 2004) and synthesised music with sea-sounds (Nilsson et al., 2001). Quasi-preferred music, by contrast, has been more inclusive and some studies have provided twenty different musical genres ranging from classical to country and western for participants to choose from and change as desired (McCaffrey and Good, 2000). Quasi-preferred music is an excellent method of providing participants with a wide-variety of optional extracts. However, despite the differences in styles and composition, generally all types of quasi-preferred music from all genres are grouped together as a singular ‘music group’ upon analysis. For example, Lee et al. (2004) used world music, or easy listening music categorised together as different options within a single ‘music group’. In the same way, Lee et al. (2005b) used Chinese classical music, religious music, western classical music or natural sounds as choices within the experimental music group. Schneider et al. (2001) also used one music group, but included in this group an even wider range of musical options: international pop, German pop, oldies, meditation music, rock music, techno and traditional classical instrumental music. A cursory glance at this list would suggest that perhaps the methodology of the study may be an over-simplification of the reality ‘music’ by the inclusion of such diverse genres as meditation music and techno music within a single ‘music’ group.

A significant number of quasi-preferred music and pain studies have used the same typology of music, that proposed by Good et al. (1999). The typology involves five musical extracts, each from a differing genre: new age synthesiser music, 1940s–1980s popular music played on the piano, classical orchestral music, popular and new age harp music and slow modern jazz music (see Good et al., 1999, 2002, 2005; Phumdoung and Good, 2003; Voss et al., 2004). Voss et al. (2004) added world music played on the Indian flute to the five examples as a culturally relevant choice. Within this ty-

pology, it seems that the genres involved are extremely different. New age synthesiser music is conceptually quite different from slow modern jazz. Yet they have all been analysed together as part of a single music intervention group. The factor which was used to rationalise the combination of genres was the concept of ‘sedative music’: music which has a regular pulse that models the resting pulse rate of 60–80 bpm. These studies have therefore used categorisation separation by group, but the musical choices show rational cohesion by way of compositional constructs as will be addressed in the next section.

It seems then that music medicine research has tended towards a *music versus no music* experimental design, whether or not the music group includes an array of different genres. When genres are so clearly recognisable to the music listener and can be grouped as such with ease (Little and Zuckerman, 1986; Diehl et al., 1983), such research may be neglecting the rich variety of compositional and cultural differences that separate genres. Compositionally, genres are not necessarily comparable and therefore the single ‘music’ group used by so much research potentially contains many different ‘musics’ which are contributing to the listener in different ways. Though genre is not an appropriate method of categorising for music medicine research due to the proliferation of possible groups, it is a consideration when assessing the cohesion of the music chosen for research. It also provides a possibility to look deeper at the music in order to see, compositionally, what makes genres different. It is possible therefore that compositional constructs would provide a clearer rationale for group differences that would go beyond simplistic genre description and into the architecture of the music itself.

## 4.4 Compositional Construction

Having assessed the complexities of categorising music by genre and in light of the difficulty that multiplicitous genres would present to clinical research, it is important to investigate potential methods of categorisation by compositional construction. Hargreaves and North (1997) constructed a pyramid to represent the intricacy of musical construction. At the peak of the pyramid is the holistic concept of a ‘musical work’. The musical work is the result of the contributions of the lower pyramidal levels: the style of the period, the style of the genre, the style of the composer, the reference sys-

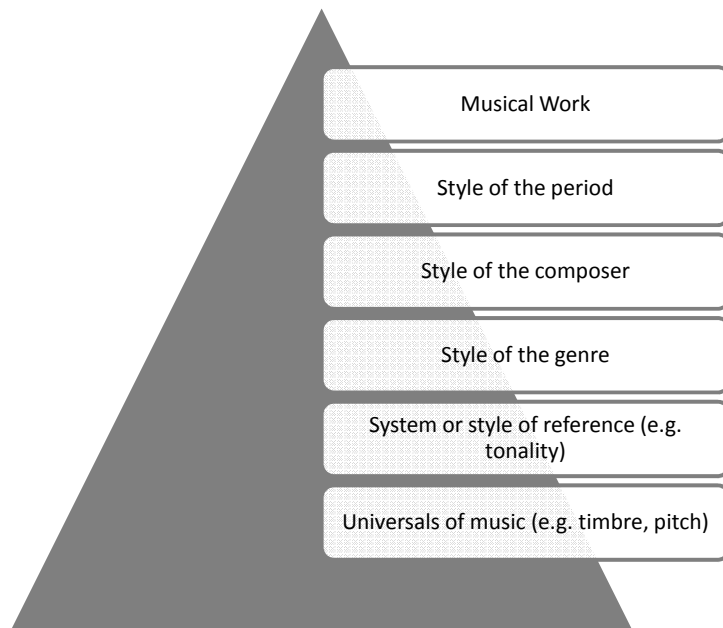


Figure 4.1: The influence of different levels of construction and style on the total musical work (following Hargreaves and North, 1997)

tem and the syntactical universals of music. It has been outlined above why genre is not a practicable method of musical categorisation, and style of the period and style of the composer are similarly wide concepts which may be unmanageable in an experimental context. Just as genre has a multiplicity of different categories, there have been many different historical ‘periods’ of music, from Baroque to 20<sup>th</sup> Century, amongst others. Likewise, there have been centuries of different composers, each composer with their own stylistic flair, and it is therefore not possible to investigate finitely the style of every composer in experimental research. It is a more viable and more applicable endeavour to look lower in the pyramid to the reference systems and universals of music. Through these levels it may be possible to find compositional constructs which could be used categorically to delineate salient experimental groups which could illuminate the question surrounding ‘what’ music can be used for pain management and ‘what’ within the music may precipitate benefits for patients.

To look first then at the categorisation that has occurred in music medicine research thus far. Outlined in Chapter 3 was the role of preference as a categorisation rationale.

It was determined that this was a viable choice, and that quasi-preferred music was to be used in this thesis. Within quasi-preferred music it then becomes necessary to select appropriate musical examples—to categorise the quasi-preferred music in line with a research rationale. The predominant method of musical categorisation has been that advocated by Professor Marion Good as ‘sedative versus excitative’ music. Sedative music has been defined by Good et al. (2000) as music without lyrics and with a sustained melodic quality. It must have a tempo that models the resting pulse: between 60 and 80 beats per minute. Sedative music must also show a general absence of strong rhythms or percussion.<sup>1</sup> Excitative music has not been tested in music medicine research, but Good hypothesised that excitative music is the opposite of sedative music: music with a heavy rhythmic content and a strong pulse. Lyrics may or may not be included and sustained melody is not a requirement. Sedative music is thought to be non-arousing and relaxing and excitative music incites arousal and activity.

For research purposes, music which includes audible and decipherable lyrics is not appropriate for inclusion in this clinical research study for reasons of personal and emotional salience (see Section 3.3.5). Lyrics are often descriptive and could predispose the patient to think of the situation or feelings that are being depicted. This may positively or negatively bias the psychological state of the participant and may have concomitant physiological effects. Listening to lyrics that describe events may also invoke patients to use additional cognitive-coping strategies alongside the music listening. Guided imagery, for example, uses vocal description of locations and events to enable listeners to transcend their current context and relax in the world described in the lyrics. This would problematise the analysis of results as some participants may have used multiple interventional strategies during their research period. Lyrics are therefore deemed inappropriate for research into music and medicine.

It appears that in the context of therapeutic music listening in a post-operative setting, sedative music has been predominantly viewed as beneficial and excitative music as material to avoid. Though this delineation is a rational methodological choice on the part of the researchers, it is possible that excitative music could be as advantageous as sedative music—this simply has not been comprehensively tested. Preferred music chosen by participants in the studies by MacDonald et al. (2003) and Mitchell et al. (2006) will have included some excitative music as chosen by participants. Though the results were equivocal, preferred music did promote anxiety reduction and improve

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<sup>1</sup>Sedative music is equated with ‘anxiolytic music’ as described by Lee et al. (2005b). The characteristics of anxiolytic music have been defined as that music with simple, repetitive rhythms, predictable dynamics, low pitch, slow tempo and consonant harmony.



pain tolerance. It is possible also that excitative music may have an advantage over sedative music in the promotion of positive mood states. Early research by LeBlanc et al. (1988) investigated the impact of slow, moderately slow, moderately fast and fast tempi on preference for traditional jazz music. Approximately one thousand students were asked to rate their preference for the music. The results showed that each increase in tempo correlated with a corresponding increase in preference rating. The greatest increase in preference was seen between moderately slow and moderately fast music. This tempo preference effect was similar in all age groups and was corroborated by behavioural evidence as faster music invoked rhythmic responses such as moving or tapping to the beat of the music. Smiling occurred more frequently during fast music and slow tempos provoked expressions of condescension or disdain. Whilst this research is not in a clinical context and surgical patients may desire different facets of music to healthy participants, it does show that there may be potential benefits of excitative music.

Excitative music may not simply depend on tempo, however, and harmonicness may also be an influential factor. Dalla Bella et al. (2001) investigated the impact of major mode and fast music, minor mode and sad music on the emotional responses and personal preferences of 24 adults and 30 children aged from 3–8 years old. The results showed that faster tempi were typically preferred to a greater extent than slow tempi. This sensitivity to tempo emerged significantly earlier than sensitivity to mode, as children under 5 years of age rated exclusively according to tempo, whereas by age 6–8 years, children perceived tempo and mode as inclusively as adults. As expected, fast and major music evoked happy mood states and minor and slow music predisposed the listener to a sad mood state. These research studies show that though much music medicine literature has utilised the sedative/excitative divide, these descriptors are actually dependent on lower level compositional constructs: pulse/tempo and mode. Broadening these two concepts, they could be termed ‘harmonicness’ and ‘rhythmicity’. The parameters of harmonicness and rhythmicity are therefore both important in the categorisation of music as sedative or excitative. Other factors such as timbre or instrumentation may also contribute, but it is not practicable to assess the entirety of musical compositional constructs in a single clinical study. The research reviewed thus far and the importance of a clear clinical methodology dictates that a choice may be made about which categorisation constructs are to be used in the course of this research study. In light of the aim to investigate the contribution of within-music factors in the promotion of audio-analgesia, work must be undertaken to manipulate the

musical intervention itself in clinical research. As the constructs of harmonicity and rhythmicity are implicitly part of all music, they represent an excellent starting point for such research. Investigating harmonicity and rhythmicity will not finitely answer all questions surrounding ‘why’ audio-analgesia may be effective, but may generate a greater knowledge of the operant nature of audio-analgesia. Therefore the compositional constructs that are to be discussed in this chapter will be restricted solely to harmonicity and rhythmicity.

Harmonicity and rhythmicity are bio-active parameters thought to function across music listening in repose (see Good et al., 1999, 2000, 2002; Good, 2008) and on movement (see Thaut, 1990, 2005). This is important as a taxonomy of music for medical purposes must focus not only on what sounds distinctive but also on what is capable of effecting biological, psychological or social change in both acute and chronic pain patients. If the success of an intervention is to be judged, it must be applicable to all possible contexts of music listening. Music is often listened to whilst relaxing, but is also regularly employed when involved in activity and movement. Hence the choice of categorisation constructs must be applicable to all possible states and all possible pain conditions. In this chapter, an attempt will be made to define harmonicity and rhythmicity, to elucidate their origins in the nervous system and to précis the key literature in the area to date. Harmonicity and rhythmicity are chosen as categorisation methods based upon the integrality of both concepts in the music medicine research which has gone before—principally sedative and excitative music. The choice to investigate musical compositional elements is to look specifically into the questions surrounding ‘what’ music (essentially what structural features of music) make music definable and bio-active as such.

For the purposes of clarity, any reference to ‘music’ in this chapter indicates sound produced directly or indirectly by humans, which may vary in pitch, timbre, metre and/or rhythm. These sounds are often made to convey emotions and for enjoyment and may have a complex structure, though this is not a requirement (following McDermott and Hauser, 2005). Tonality refers to the organisation of pitches in a way in which one central pitch dominates and attracts the others and gives name to the key (Krumhansl, 2000). Musical syntax refers to particular scales and melodies; musical grammar to the rules of composition; and musical notation to the score itself (Warren, 1999). Processing music is conceptualised as a complex set of perceptive and cognitive operations correlated with memory and the understanding of emotion (Andrade and Bhattacharya, 2003). Music processing has both global (holistic) and local (analytical)

elements and the broad terms of harmonicity and rhythmicity are both viewed in holistic or global terms. Within harmonicity, pitch intervals are local and melodic contours or hierarchical structures are global (Andrade and Bhattacharya, 2003). Rhythmicity is local in respect of the perception of note duration and temporal distance. Metre, as the temporal variance of recurrent pulses, is global. Beyond this, the term ‘innate’ is taken to mean traits determined by (genetic) factors present in an individual from birth. This includes traits that are immediately identifiable in infants, in addition to those traits which may not emerge until later in development, for example at puberty (McDermott and Hauser, 2005).

#### 4.4.1 Harmonicity

Harmonicity is a global concept which reflects the consonance of music in relation to the harmonic series. The lowest note played is considered to be the bass or fundamental note, and the fundamental is ultimately the perceived pitch of a note. Pitch is therefore the auditory percept connected with the frequency of a sound (Tramo et al., 2005). The acoustic make-up of the fundamental contains higher overtones or harmonics which are integer multiples of the fundamental (Baines and Borthwick, 2008) and form the ‘harmonic series’. Harmonics rise in pitch, with each harmonic twice the wavelength and half of the frequency of the preceding harmonic, beginning with the fundamental (see Figure 4.2). The higher in the series, the smaller the interval between the harmonics becomes. Each harmonic may be expressed as a ratio of the two notes involved, thus C–C is the simplest at 1:2 (the octave) and C–G as 2:3 is a perfect 5th. Harmonics vary in their predominance in sound and harmonics with simple ratios indicate the strongest pitches (e.g. C–C at 1:2 is stronger than 23:24 which represents three-quarters of a semitone) (Baines and Borthwick, 2008). When frequency components are harmonically related, the resulting percept sounds strong, but frequency components which are not harmonically related create weaker pitch percepts and dissonant intervals and chords (Tramo et al., 2005). The frequency of a true harmonic is adjusted slightly in Western tonal music to create the equal tempered scale. The equal tempered scale uses the first harmonic (the octave) broken into twelve equal steps (semitones) and is maximally 6% different from the pure tone (Krumhansl and Toiviainen, 2001). The number and ratio of harmonics in a sound give each instrument/sound its individual tone quality. Harmonics are rarely perceived individually, but are grouped together by the ear and are collectively perceived as tone colour or timbre.

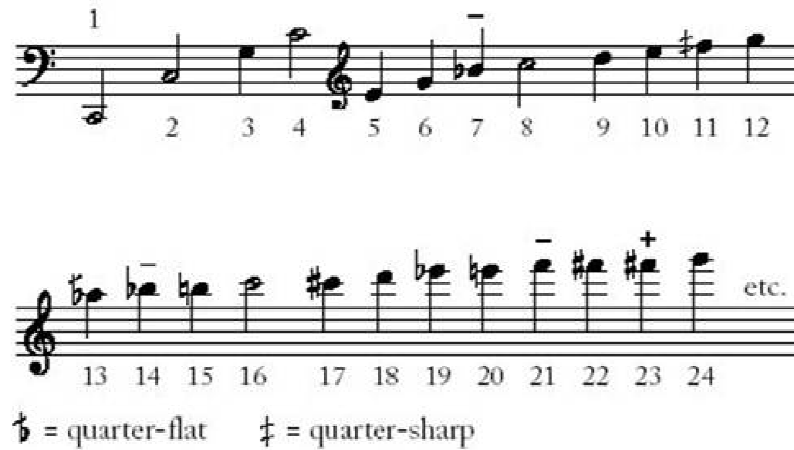


Figure 4.2: The first 24 harmonics of the harmonic series when C is the fundamental (taken from Baines and Borthwick, 2008)

Having summarised the harmonic series, is the series just an academic convention, or has it been validated with in-subjects experimental research? Auditory pathways are hard-wired to deal with acoustic stimuli. The universality of music seems an increasingly stable fact. Every known human culture in the past and in the present has included some form of music (McDermott and Hauser, 2005). It is this fact that has led many musicologists to search for a rationale for music: if music is universal, what evolutionary advantage has music conferred? Where sleep or sexual relations have evident evolutionary rationales for increasing energy levels, healing the body and for procreation, music has not yet revealed its evolutionary role in survival. Yet musicological research has shown a degree of cross-cultural homogeneity, with all world music systems showing octave and small-integer ratio primacy (Trainor, 2006). Every developed musical system recognised by Western scholars is founded to some extent on octave similarity (McDermott and Hauser, 2005). In the same way, most known musical cultures function around a small set of musical pitches which are repeated at the octave. The set of pitches generally includes 5–7 notes arranged some form of series or scale, be it diatonic, pentatonic or similar (McDermott and Hauser, 2005). This has been validated through the archaeological discovery of ancient Neanderthal and Chinese flutes which, when played, produce sounds which approximate the diatonic

scale and adhere to the harmonic series (McDermott and Hauser, 2005).

Is there then a human need for musical organisation? Is the human auditory system predisposed to hierarchical musical sound? It is thought that scalar organisation in all cultures is based on unequal stepped tones derived from the harmonic series (McDermott and Hauser, 2005). In the Western diatonic tradition, tones and semitones are ordered together into scales and keys. These keys do not contain equal intervals or 'steps', but are instead built on unequal steps. It has been theorised that unequal steps enable listeners to identify the function of different notes and to recognise instantly melodies as they can perceive the hierarchical functional role of notes in a melody (McDermott and Hauser, 2005). Trehub et al. (1999) compared the ability of adult listeners and 9 month old infants to detect mistuned notes (1.5 semitones removed from the original) in familiar and unfamiliar, equal and unequal stepped scales. Infants were able to recognise mistunings on familiar and unfamiliar unequal step scales, but adults were only able to identify discrepancies in the familiar unequal step scale. This research suggests that unequal steps in scales are preferred and better understood by infants and adults alike. Unequal steps also facilitate the memorisation of melodies for infants and adults, but consistent exposure to one musical tradition renders adults limited to the accurate identification music of their own (familiar, unequal step) scale system and their generic ability to identify melodies of different scale systems decreases.

The preference for unequal stepped scales is a cross-cultural commonality. American infants could accurately discern perturbations to both Western scales and Japanese scales (Lynch et al., 1990). In addition, in cultures where pitch is important for language, unequal scale and pitch perception may be even more developed than in Western children, for example. Trehub et al. (2008) found that 5-year-old Japanese children had a better recognition for pitch and a better memory for absolute pitch than older American or Canadian children. Japanese language requires pitch accent recognition, whereas English is a stress accent language and does not require such accuracy in pitch perception. In early childhood the ability to listen and discern disturbances in a wide variety of musical scales is evident, but this declines by adulthood. Infants therefore display a greater degree of musical open-earedness than adults, though they have the same preferences for unequal stepped scales and similar abilities to recognise experimental perturbations.

Research into melody recognition with infants has implicated melody recognition as an innate ability in humans. Infants are most sensitive to melodies which are tonal

and tonal melodies are most easily recognised. 'Atonal' melodies which do not include unequal stepped scales and are not in a single key are more difficult (Trehub et al., 1990). At two months of age, infants' brains are activated in response to unexpected changes in melodies (Trainor et al., 2003). As early as 8-months-old, experimental manipulations in melodies are recognised and responded to by infants (Trehub et al., 1984). When a familiar melody is transposed to a different key, but the pitch contour remains the same, infants recognise this as a familiar melody and orient longer to the familiar stimuli than to the unfamiliar stimuli (Trehub et al., 1984). Infants therefore rely on a sense of relative pitch (Plantinga and Trainor, 2005), identifying contour and patterning in melodies but not absolute frequencies, unlike primates. It is thought that this ability to recognise melody and to discern melodic deviance is related to the simplicity of the frequencies of ratio intervals commonly in used in melody. Simple ratios are thought to function as memory aids to listeners as they allow melody recognition and may have direct correspondences in the architecture of the auditory system (McDermott and Hauser, 2005). Simple ratios are common across other cultures, generations and musical backgrounds (Tramo et al., 2001) and the prevalence of the most simple intervals (octave, perfect 5<sup>th</sup>, 4<sup>th</sup> and 3<sup>rd</sup>) in Western musical compositions is indicative of the ease of processing that they allow.

Certainly, interval perception is significantly better for intervals of simple tones than of complex tones. Schellenberg and Trehub (1996) asked both adults and 6-year old children to detect changes from intervals with simple frequency ratios to those with complex ratios, and vice versa. Adults and children with no musical training performed better on the changes from simple ratios (1:2, 2:3 or 3:4) to complex ratios (8:15, 15:32 or 32:45) than when complex intervals were sounded first. Schellenberg and Trehub assert that this difference is due to the greater degree of perceptual coherence in simple frequency ratios than in complex ratios. Scales with unequal steps create simple frequency ratios, and this could therefore explain the preference for unequal stepped scales and simple intervals across musical cultures. In a comparable study, Trainor (1997) evaluated the effect of frequency ratio simplicity on the processing of simultaneous pitch intervals. When the change was from a simple interval to a complex interval (for example a perfect 5<sup>th</sup> (2:3) to a tritone (32:45)), performance was significantly speeded than in reverse. Therefore simultaneous and sequential intervals in simple ratios are easier to process in early infancy and this effect is consistent throughout adulthood.

The effect of simple intervals serves to identify sound as ‘consonant’ sound. Sounds are perceived of as consonant (simple ratios which adhere to the harmonic series) or dissonant (complex ratios, rough sounds and causative of tonal tension) (Palisca and Moore, 2008). Consonant music is harmonious, agreeable and stable; dissonant music is disagreeable, unpleasant and in need of resolution (McDermott and Hauser, 2005). Consonant intervals have harmonically-related bass fundamentals, whereas dissonant intervals show no such temporal regularity in the acoustic waveform and no strong representation of any pitch below the notes in the interval (Tramo et al., 2001). Choosing consonance over dissonance appears to be a natural inclination. Two studies by Trainor and Heinmiller (1998) required 4-month-old infants to listen to consonant or dissonant intervals (Experiment 1), and (Experiment 2) to a consonant or dissonant version of a Mozart minuet. Infants looked for longer at a speaker playing consonant music, and their evaluative reactions to the dissonant music paralleled the responses of adults.

Consonance and dissonance also have attentional consequences. Trainor et al. (2002) investigated the attentional impact of consonance and dissonance on infants. 2- and 4-month-old infants were exposed to a looking-time preference procedure, with time spent looking at the speaker/sound source as an indication of preference for that stimulus. Additionally, consonant intervals garnered the most attention and looking time, but a series of dissonant intervals caused the infants to cognitively and physically disengage from the trial and it was difficult to regain their attention. Consonant and dissonant music also evoke differentiation in the behavioural responses of infants. In research with complete melodies, Zentner and Kagan (1998) found an innate preferential bias for consonance over dissonance with 4-month-old infants. The infants looked for a greater amount of time when consonant melodies were played and their behavioural responses became less motoric. Dissonant music, by contrast, provoked ‘fretting’ behaviour and infants looked away.

The acknowledgement and positive reception of consonant sound and the rejection of and dislike for dissonant sound seems to be a specifically human trait. McDermott and Hauser (2004) conducted a series of studies into preferences for consonance and dissonance with Cotton-top Tamarins. Tamarins were placed in a V-shaped maze, in which one branch of the V had loud white noise and the other soft white noise. Tamarins showed a significant preference for soft white noise, choosing to remain in that branch of the V. Yet when played consonant intervals on one side of the V and dissonant intervals on the other, Tamarins showed no auditory preference for the consonant intervals. Similarly they showed no distress at a screeching sound akin to

fingernails on a blackboard versus white noise and spent equal amount of time in each branch of the V. These results were diametrically opposed to those of human listeners who significantly favoured consonant intervals and showed a marked aversion to the screeching sound. Humans therefore show qualitatively different sound preferences to primates and actively seek consonance over dissonance. In addition, the active desire to listen to music and the music-seeking behaviour that is seen in humans (Sloboda, 2002) is not present in primates. McDermott and Hauser (2007) conducted another experiment using the same V-maze methodology. When given the choice between slow, soft, lullaby music or silence, Tamarins and Marmosets actively displayed a preference for silence. Humans, by comparison, chose to listen to the music instead of remaining in silence.

It may be that music, and in particular music with simple ratios and consonant sound correlates with a greater ability to recognise and process the sound, than dissonant music. As will be discussed subsequently, the auditory system and in particular the firing characteristics of the auditory nerve may reflect an innate structural bias and conditioning towards consonant sound. The early age at which preference for consonance emerges suggests that this bias may reflect an innate inclination towards positive harmonicity. In addition, it is also likely that the predilection for consonance is consolidated through the acculturation that is a result of ever-increasing years of exposure to a particular musical system such as Western tonal music. Though preference for unequal steps and consonance appears to be innate and present in humans from a very early stage in life (2 months, if not earlier), with adulthood the auditory system seems to become attuned to one particular musical culture. Adults are less able to assimilate different scales or tonal patterns and struggle more than children to notice perturbations to musics that are outwith their sphere of acculturated knowledge. Infants are more open-eared and it is likely that pitch and consonance perception enables the child to learn the musical system of their culture.

So, to what degree is music recognition or the identification of hierarchical musical structures simply a result of learned expectations of one's culture's music? Is the developed hierarchy used in Western tonal music indicative of an innate mental representation of pitch relationships? Harmony and pitch are multi-dimensional concepts. Just as two or more successive pitches comprise melodic intervals and melodies (horizontal harmonicity), two or more simultaneous pitches construct harmonic intervals and chords (vertical harmonicity) (Tramo et al., 2001, 2005). Chord progressions illustrate the musical grammar of the Western musical system. A series of chords, or



the line of a melody can create an expectation of the contour of the musical phrase in the mind of the listener. Expectancies reflect both innate and learned mental representations of tonal relationships or tonality. Just as the frequency ratios of an interval can facilitate processing, the harmonic context of a chord sequence can prime the processing of the chord and induce expectations by activating tonal representations in the mind of the listener (Leino et al., 2007).

In order to assess experimentally the nature of harmonic knowledge and the degree of acculturation that has occurred, the majority of research into harmonic hierarchies has used the ‘probe tone’ method or electrophysiological monitoring of brain function when listeners are exposed to violations of their harmonic expectations. The probe tone method primes a listener by creating expectancy in a musical line. A typical tonal chord or melodic progression occurs to set-up the experiment and the note *following* the prepared musical context is the ‘probe tone’. The probe tone method was used by Krumhansl and Toiviainen (2001) to create scale profiles which were manipulated via multi-dimensional scaling to create geometrical representations of key similarities. The 24 major and minor keys are spatially represented to best display their similarities via proximity. The closer a key/note is to another, the more related the keys/notes are. The resultant graph is termed a ‘self-organising map’ by which keys are hierarchically represented and visually accessible (Krumhansl and Toiviainen, 2001). This self-organising map is thought to be replicated neurologically. Neuroimaging has shown that adjacent sections of the auditory cortices are activated when listening to music in a particular key (Janata et al., 2002). Where the keys were next to a neighbouring key from the cycle of fifths that is so important to Western tonal music (see Figure 4.3), the activation areas were adjacent in the cortex. In this way it is thought that neural maps actually embody the psychological relations between keys (McDermott and Hauser, 2005), though more research is required to finitely prove this.

Knowledge of tonal hierarchy and key relations seem to be implicit in both musicians and non-musicians. With repeated exposure to traditional Western music, expectations are formed about the way in which tonal musical phrases should be completed. Listeners learn to anticipate the prototypical harmonic syntax (Loui et al., 2005). Listening to a musical phrase which deviates from this implicit syntactical knowledge violates expectations. Just as the probe tone method functioned as a challenge to musical expectations, electrophysiological research has used similar methodologies. Leino

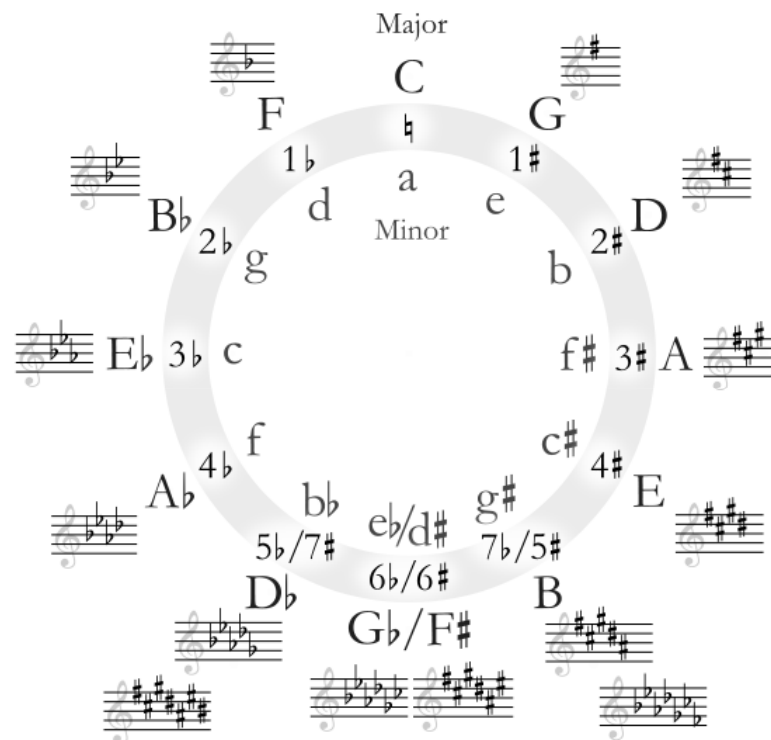


Figure 4.3: The cycle of fifths (taken from Wikipedia, 2008)

et al. (2007) examined the knowledge of and responses to harmonically congruent or harmonically incongruous chords. Ten non-musician subjects with no formal instrumental musical training (FIMT) or explicit knowledge of Western music theory listened to a series of musical sequences containing either harmonically congruent or harmonically incongruous chords. The incongruence was induced by the use of a Neapolitan Sixth ( $N^6$ ) or mis-tuned chords. The  $N^6$  is a major chord generally built upon the first inversion of the flattened supertonic.<sup>2</sup> The  $N^6$  is not an atonal or unusual chord and is regularly used in Western tonal music, but when it is played outside a traditional chord progression, it sounds out of place and violates harmonic expectation (Loui et al., 2005; Koelsch et al., 2002).

<sup>2</sup>In the key of C major, the Neapolitan Sixth would consist of the D flat major chord. D is the supertonic (second note in the scale) of C major, this is then flattened and becomes D flat. The triad of D flat major is D flat, F and A flat, so in first inversion the notes of the Neapolitan Sixth in the key of C are F, A flat and D flat.

Leino et al. (2007) used the incongruent chords (either mis-tuned or  $N^6$ ) at either position 3, 5 or 7 in a sequence of seven chords. Participants' brain activity was recorded via continuous EEG monitoring. The results showed that the  $N^6$  chords did elicit brain responses, and that this response was proportional to the degree of violation of Western harmony rules. Positions 3 and 7 represented the strongest violation of expected harmony and they exhibited greater brain activity. This was different to the result caused by mis-tuned chords placed in positions 3, 5 or 7. Mis-tuned chords did invoke brain activity, but there was no variety between chord placement positions. Where the results of the  $N^6$  incongruous chords incited differential brain responses dependent on the degree of harmonic disruption, the mis-tuned chords showed similarity for all harmonic positions. It seems then that music is processed in accordance with harmonic rules, and incongruity of all kinds is recognisable, but harmonic incongruity is highly provocative. Ultimately, the specificity of harmonic expectancy correlates with the degree of appropriateness of the musical syntax described by music theory (Maess et al., 2001). Deviant chords are incongruous on the basis of music psychology as they violate expectation, but also music theory as they represent harmonically inappropriate chord functions (Maess et al., 2001).

Brain activity in response to syntactical violations occur when people attend to music and even when they do not. Loui et al. (2005) used a Mismatch Negativity (MMN) paradigm in which a negative (incongruous) component is elicited by a deviant auditory stimulus in an ongoing stimulus train (Loui et al., 2005). The well-established five-chord progression occurring in Western music, I-Ib-IV-V-I, was used as the standard chord structure. Participants were asked to complete two conditions: attended and unattended. (1) The attended condition required participants to detect an occasional decrease in the sound intensity (volume) or any of the chords. This ensured that participants listened to all chords equally and were attentive throughout to possible volume changes. (2) The unattended condition asked subjects to study reading comprehension passages whilst listening to the music. Participants were told that they would be asked questions about the comprehension exercise and were therefore motivated to read closely. The answers to the comprehension questions were statistically analysed, thus providing behavioural data to confirm that the comprehension exercise was attended, but the music listening task was unattended. The standard chord sequence was used in 61% of trials, the  $N^6$  chord was substituted for position five in 26% of sequences and the fade-out volume chord was included in the standard sequence in 13% of the trials.

Eighteen non-musicians completed eight hundred trials of this MMN attention task, using N<sup>6</sup> and fade-out chords to invoke attention or reading comprehension to avoid attention. Event-Related Potentials (ERPs) were recorded throughout. The attended deviant condition elicited large early-onset Early Anterior Negativity patterning in the brain. ERPs were also evident in response to deviance in the unattended condition. This provides evidence that the recognition of incongruous chords is apparent in the ERPs of non-musicians, and this occurs when they are attending to the musical stimulus and when they are not. The difference that was elicited between attended and unattended conditions suggests that endogenous resource allocation is important for the neural processing of complex stimuli such as musical harmonic syntax (Loui et al., 2005). This study therefore validates the ability of non-musicians to process and comprehend musical hierarchy, but also demonstrates the way in which attentional resources do affect processing ability (see Section 2.3). Similarly, Lopez et al. (2003) found that participants in an EEG and MEG neurophysiological study were able to perceive music that deviated from the expected norms. Both musicians and non-musicians demonstrated an implicit knowledge of basic tonality rules and the results of the mismatch study validated this.

Thus far it has been outlined how music, across cultures, is often built upon small divisions of 5–7 notes which create an unequal stepped scale. From this and from the frequency relationships in the harmonic series, frequency interval ratios are apparent, the simplest of which are most easily processed and most acceptable to the ear. Preference for simple intervals is evident at only a few months of age, as is the desire to listen to consonant music over dissonant music. Hierarchical relationships between keys and in musical phrases can be identified similarly by musicians and non-musicians, and this awareness generates expectancies when listening to music. When expectancies are violated, the brain responds with unusual activity, suggesting that the plasticity of the brain can incorporate harmonic relationships as a feature of music listening. Questions then arise surrounding how does the brain process music, and where in the brain does this occur?

The majority of research into music and neuroscience refers to the ‘auditory cortex’. This is not a structural area of the brain (as may be expected), but is grey matter in the cerebral cortex where neurons respond selectively to musical stimuli and not to visual, tactile or other sensory stimuli (Tramo et al., 2005). When an acoustical signal is received, it is deconstructed and each component is distributed to the appropriate cortical areas which have adapted to process the kind of information that the signal encodes

(Warren, 1999). Cortical responses recruit colour and personal saliency through the participation of deep temporal and limbic structures. Auditory signals are ultimately communicated through the ascending auditory pathways. These are a hierarchy of brainstem structures, terminating in the auditory cortices (Warren, 1999).

The right and left hemispheric auditory cortices are different in their construction: the left auditory cortex has an advantage for fine temporal processing and the right for fine spectral processing (Zatorre, 2003). The left hemisphere is involved in the analysis of fine structure in time—rhythm and the identification of ‘space’. This included the processing of pitch intervals on a mental stave, and the recognition of familiar music from memory stores (Warren, 1999). The right hemisphere perceives colour, defined as timbre, and contour and melody (Warren, 1999). Through simultaneous sound processing in the right and left auditory cortices, information combines together rapidly to resolve temporal and frequency processing domains (Zatorre et al., 2002). With the ability to process spectral signals, the right auditory cortex is central to pitch processing. The right hemisphere is also implicated in the specialisation of working memory for pitch, essentially the short-term retention of tonal patterns (Andrade and Bhattacharya, 2003).

The left auditory cortex is primarily concerned with metre and rhythm perception (see Section 4.4.2). Though there may be some plasticity in hemispheric dominance in response to the number of years spent in musical training (Ohnishi et al., 2001), ultimately there is a left-right divide which reflects harmonic-temporal structure and information processing. In confirmation of this hypothesis, Ohnishi et al. (2001) asked fourteen Japanese music students and fourteen age and gender matched Japanese non-musicians to undergo an fMRI whilst listening to the melody of some unfamiliar music. The magnetic resonance imagery results showed a marked right hemispheric predominance for all subjects. Musicians also displayed some left hemispheric activity in the temporal cortex which was related to the age at which the musicians had commenced their formal instrumental musical training.

Much of the knowledge about music processing in the brain has come from studies involving patients with disease-related inhibitions in their perception of music. The principal condition is that of ‘amusia’, meaning an inability to recognise musical tones or rhythms, or to reproduce them. Amusia exists in a variety of forms and not all patients show complete musical perceptual incapacitation (Munte et al., 1998; Schuppert et al., 2000). Patients who experience lesions in their right auditory cortex as a result of a medical condition can experience pitch perception deficits (McDermott and Hauser,

2005). Right cortical damage can also cause dysfunction in the processing of pitch distance and pitch change (Tramo et al., 2005; Neuhaus and Knösche, 2008). Where the left auditory cortex has malfunctioned for genetic or medical reasons, problems may occur with rhythm identification and production, timing perception and any form of rhythmic discriminatory activity (Neuhaus and Knösche, 2008).

Having reviewed the literature on harmonicity, there is significant evidence to provide a rationale for the inclusion of harmonicity as a key categorisation construct for further research into music and pain. Harmonicity is a fundamental contributor to the concepts of sedative and excitative music that have already been included in medical research, and therefore it is a logical extension to evaluate the specific contribution of harmonicity in greater detail through this thesis. Harmonicity is viewed as a global concept which reflects consonance versus dissonance, tonal hierarchical sound versus atonality, which adheres to or disregards the harmonic series and involves simplistic or complex intervals.

Although harmonicity is innately a continuum, for the purposes of this thesis, the extremes of the scale—high and low—are used to provide the most salient level of harmonic differentiation. High harmonicity is therefore characterised by sonorous, agreeable and stable music, and low harmonicity by non-harmonic, disagreeable music which is in need of resolution. A definition is outlined on page 96. As non-musicians respond to issues within harmonicity with as great an ability to process the acoustical signal and respond to the sound as musicians, harmonicity is considered to be a concept which is accessible to all, whatever their level of musical expertise. Music is so universal that it is generally encountered in some form on a daily basis. Therefore all people are to some degree ‘educated listeners’ even though they may not have undergone Formal Instrumental Musical Tuition. The ability of non-musicians to recognise and categorise harmonicity as high or low is tested in a pilot study described below (see Section 4.6).

#### **4.4.2 Rhythmicity**

Harmonicity is fundamental to music perception, but what is the role of rhythmicity; indeed, what is rhythmicity? This section will attempt to answer these fundamental questions with reference to recent studies into perception of rhythmicity. Research with experienced musicians has shown that listening to experimental stimuli which are formed either only using harmonicity (melodic contour, but isochronous pulses)

or just rhythm (differences between pulses, but no change in melodic contour) it is still possible to judge the music effectively (Neuhaus and Knösche, 2008; Palmer and Krumhansl, 1987). When asked to listen to familiar folk songs, it was still possible to recognise the songs even when isochronous tone sequences were used. So harmonicity and rhythmicity are separate dimensions and are discriminable as such, but yet they are tied together in all music. Though music may be thought of as a primarily harmonic and melodic medium, in some cultures pitch can be tangential, for example in the many African musical styles which are propelled and directed by heavy rhythms (McDermott and Hauser, 2005). Why is this and what does rhythmicity offer to the listener?

Temporal structure in music is formed through syntactical levels. Figure 4.4 represents the different levels through the subdivision of a short rhythmical phrase. At the top level, represented by musical notation, is the ‘rhythm’ of a piece. Rhythm refers to the changing temporal patterning of event durations in an auditory sequence (Large and Palmer, 2002). In musical terms, rhythm corresponds to the note lengths and combinations chosen by the composer. Rhythm allows the composer to create meaningful sound patterns in time (Thaut, 2005). Below this are two levels which represent the ‘beat’. The ‘beat’ defines perceived pulses that mark equally spaced (subjectively isochronous) points in time, either sounded in the rhythm or inferred, hypothetical, unsounded event time points (Large and Palmer, 2002). Beat covers two levels because it is to some extent an abstract temporal structure in music, including multiple nested periodic structures (Hannon and Johnson, 2005). Beat level 1 refers to the strong beat that is heard in music and beat level 2 indicates the metre or pulse of the music, which is an isochronous alternation of strong and weak beats over time (Large and Palmer, 2002). It is at this beat level 2 that the majority of people tap or move to the music. Metre is generally divisible into duple (in two or four) or triple temporal structures, as shown in Figure 4.4. It is metre that is the primary construct in rhythmicity and that will be predominantly addressed in this section.

To consider rhythmicity musicologically, it is likely that metre is inferred from a number of different distributional cues: accents and melody in particular. Accents, points of focal stress harmonically or rhythmically in music, are thought to be key to the perception of metrical regularity. Accents can be longer, louder, higher in pitch, positioned at points of change in a melody or at melodic or rhythmic phrase boundaries (Hannon and Johnson, 2005). Accents are most common in positions of metri-

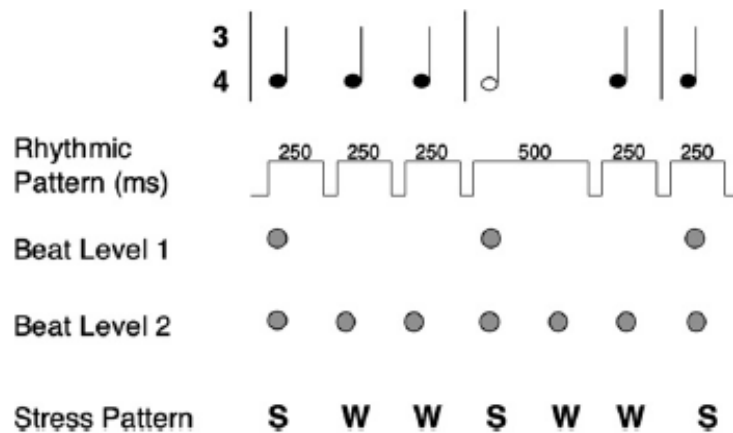


Figure 4.4: Levels of rhythmicity. At the top level is the musical notational representation of a rhythm. This is a rhythmic pattern including events of different temporal duration, as indicated by the millisecond markings. Strong (S) and weak (W) beats arise from the metrical hierarchy and above this are two isochronous beat levels (reproduced with permission from Hannon and Johnson, 2005).

cal strength and thus can aid the perception of metre (Lerdahl and Jackendoff, 1983). Via accent-cued periodic temporal structures, metre serves to draw attention to musical hierarchical harmonic events and aids learning about pitch relations (Plantinga and Trainor, 2005). Metre could also be perceived from melodic leads. New melodic phrases tend to begin and end in fidelity with the metre. Similarly, performers often mark metrical events through varying the sound event intensity or duration (Large and Palmer, 2002). Whatever the musicological reason for metrical perception, the reality is that metre is inferred with little problem by listeners.

When listening to a piece of music, trained and untrained listeners easily perceive regularity in the sound: they are hearing the ‘beat’. Even without musical training, it is possible to clap, click, sway or dance with the beat of the music. It is this unique ability of the majority of normal music listeners (e.g. listeners without any form of amusia or formal musical training) to listen to musical sound and perceive a ‘beat’ that is important. Listeners are sensitive to all levels of temporal structure within a piece of music, and easily differentiate the levels and infer the most salient level: beat level 2, the metre. Rhythm is evidenced by specific patterns of temporal intervals chosen



by the composer and is clearly audible. Metre is more subtle and is sometimes heard and sometimes inferred from periodic regularities within the musical surface (Hannon and Johnson, 2005). Metre is not a metronomic occurrence and its perception is not uniform throughout a piece of music. Metre is a dynamic concept that is perceived through a desire for regularity and is constantly adjusted so that regularity is maintained and the metre fits the music that is heard (Temperley and Sleator, 1999).

Metre adheres to a 'regularity rule', whereby beats are perceived and preferred when they are maximally evenly spaced (Temperley and Sleator, 1999). It is entirely possible for rhythm and metre to conflict, and indeed this can be a deliberate compositional strategy (for example the use of hemiolas). Despite rhythmic variation, once a sense of beat or metre has been established, it can continue with ease in the mind of the listener even if the train of temporal events diverges for a short period (Large and Palmer, 2002). Similarly, if a strong metrical pulse has been created, this can persist for the listener even after the music has ceased. It seems then that rhythmicity may have developed in response to our own behavioural and psychological need for organisation.

Listeners' ability to perceive the beat is so effortless and so universal, that it is possible that rhythmic perception is an innate mechanism. It is thought that the structural organisation and time code of music and metre actually models or resembles the oscillatory rhythmic firing of neural information in the brain (Thaut, 2005). In this way, music has evolved a temporal grammar which may parallel how the brain codes information. It is this intimate connection between neural programming and rhythm that can explain the ability of rhythmic sounds to entrain rhythmic activity. If music can replicate neural rhythms, then it has the potential to communicate sensory and cognitive-perceptual information to the brain (Thaut, 2005). In this way, music and rhythmical cuing mechanisms have been therapeutically applied to movement dysfunction problems induced by medical conditions such as Parkinson's Disease, Stroke patients, Traumatic Brain Injury and Multiple Sclerosis sufferers. When neural firing patterns are irregular and performing poorly, music can serve to regulate neural function and provide a template for the activation of movement patterns or thought processes through entrainment. The strength of the timing mechanisms in music are related to the mechanisms in the CNS that control the timing, sequencing and co-ordination of movement (Thaut, 2003).

Synchronised co-ordination of regular, repetitive movement to music has been found in all known cultures, therefore metre must, to some degree, constitute a uni-

versality in music perception and behaviour (Hannon and Johnson, 2005). Only the human race has a proven ability to maintain a steady beat with one another, and this skill is not evident in primates (Daveson and Skewes, 2002). The extremely high inter-subject agreement in metrical synchronisation tasks suggests that metrical structure can be easily grasped by all listeners (see Drake et al., 2000, for an example of a synchronised tapping task). As rhythmicity enables the anticipation of musical events, metre thereby serves to facilitate neural anticipation of muscular activity (e.g. clapping, dancing or walking with the beat). Rhythmicity is innately connected to the sensorimotor system and the strong timing mechanisms in music are thought to entrain oscillatory circuits in the brain, regulating movement (Thaut, 2005). Music, with its innate temporality, creates meaningful sound patterns in time and therefore simulates or resembles the oscillatory 'rhythmic' synchronisation codes of neural flow and processing in the brain (Prassas et al., 1997; Suteerawattananon et al., 2004; Thaut, 2005). Music, through rhythmicity, is therefore a powerful stimulus which evokes sensory, cognitive-perceptive and motor components by priming the brain and muscles for action. Rhythm is uniquely privileged in its position as a regulator and generator of movement and in its ability to assist neural processing. The therapeutic importance of metre cannot be underestimated in this regard.

If metre can facilitate neural firing patterns and direct movement, then it would seem logical that metre perception must be consistently evident in infants from a young age. Though there inevitably may be an element of cultural conditioning in the perception of metre, from an early age temporal regularity is salient to young infants. Mothers bounce and rock their children and often sing to them lullabies which are metrically simplistic and are accompanied by rhythmic behaviours (Papousek, 1996). Hannon and Johnson (2005) conducted a series of three experiments with twenty-four seven-month-old infants. In the first experiment, infants were habituated to three rhythms that contained the same underlying metre. After habituation, the looking paradigm was used to investigate preference for rhythm. Infants gazed for longer towards new rhythms with novel metres, rather than familiar metre stimuli. The authors suggest that this indicates that infants have inferred the underlying metre in the habituation stimuli, and following this, preferred to listen to the novel metrical stimuli. To ensure that this was not a function of metrical or rhythmic grouping constraints, a second experiment was conducted with another twenty-four seven-month-olds. Groups were defined as any series of events that were bordered on both sides by silence (rests). Groups were habituated in a single metre and post-habituation results showed that the infants pre-

ferred the novel metre and familiar grouping structures, rather than familiar metre and unfamiliar grouping structures. This suggests a consistent preference for novel metre.

In the third and final experiment, Hannon and Johnson moved away from just rhythms, and towards music. Seven-month-olds were played melodies which consistently allocated pitches to metrically strong positions or the opposite pitch set to metrically weak positions. Non-rhythmic, isochronous versions of the same melodies acted as a control condition. The whole-tone scale was used to construct the melodies so that there was no function of acculturated knowledge of the Western diatonic scale which may have proffered some infants an advantage. If infants learned to associate certain pitches with metrically strong or weak positions, then they would show a novelty preference for novel tone distributions. The results of the study showed that infants in the experimental group oriented for longer to the novel melodies. This suggests that infants learned to associate pitch event with metrical structure. The infants with isochronous melodies showed no preference for familiar or unfamiliar pitches. The results of the work by Hannon and Johnson suggest that that infants are able to grasp metrical structure at an early stage of life. From this temporal structure, they are able to use metre as a framework for learning pitch structure. This is thought to have resultant attentional benefits, as was also demonstrated for high harmonicity. By identifying regularity and metre in sound, infants may be able to interpret and organise musical information with greater ease (Hannon and Johnson, 2005). Metre therefore to some degree acts as a 'chunking' mechanism which helps the encoding of new information and acts as an aid to memorisation and learning (Hannon and Johnson, 2005; Large and Jones, 1999; Palmer and Pfordresher, 2003). An important facet of rhythmicity is its organisational ability (Daveson and Skewes, 2002).

Though rhythmicity can stand alone external to harmonicity, the interconnectivity between the two and the importance of their relationship for the purposes of musical information processing is paramount. Metre perception in particular involves both harmonic and rhythmic processing, as explicated by the need to identify events which contribute to metre at multiple levels of the musical surface (see page 90). Hannon et al. (2004) investigated the different cues that aided participants in perceiving musical metre. Through a series of experiments, melodic and temporal accents were compared. Melodic accents involved contour change, melodic leaps, registral extremes, melodic repetition and harmonic rhythm. The results showed that when rhythm was isochronous, melodic contour change and repetition facilitated metre judgements most efficiently. When temporal constructs were varied, accents, tempo and contour change

predicted metre perception. The listeners therefore were utilising both rhythmic and harmonic facets to process the musical stimuli and these together contributed to a feeling of musical metre.

The neurological connection between rhythmicity and harmonicity was shown by Neuhaus and Knösche (2008). Fourteen musicians and fifteen non-musicians listened to melodies which were controlled in four ways for harmonicity and rhythmicity. Participants were monitored for their brain activity through event-related potentials. The four possible melodies occurred as: (1) an unchanged order of pitches and durations; (2) preserved pitch order, but randomised time order; (3) time order was preserved and pitch order randomised; and (4) time and pitch order were both permuted over the entire set of tones. Subjects were asked to listen carefully to the stimuli and to identify (if possible) whether the following stimulus was the same or different to the melody that had played before. The results of the study showed that pitch and temporal factors significantly interact. Both duration and pitch properties of tones were key to recognising stimulus similarity. When rhythmic order is permuted, ERP amplitudes increase and recognition ability is lowered. Overall, randomised sequences showed greater ERP activity than non-random examples, suggesting that listeners had to work harder to process the stimuli as they were outside of normative hierarchical temporal or harmonic structures.

Rhythmicity has traditionally been viewed as musical temporal activity which is preferentially processed in the left hemisphere of the brain (Andrade and Bhattacharya, 2003). Though this is a predominant viewpoint, the left-hemispheric lateralisation is not as clear-cut as for pitch processing. Metre, in particular is thought to show little or no hemispheric lateralisation (Warren, 1999). It may be that the left hemispheric specialisation for rhythm and the processing of pitch space or melody identification, require equal involvement of the working memory structures of the right hemisphere. Metre may require greater organisational perception and therefore may, to some degree, depend on connections with working memory. Further research is needed to clarify this situation. What is evident, however, is that as with harmonic processing, there is some structural cross-over in the central nervous system.

Rhythmicity, considered as temporal regularity and metrical consistency in sound, is a highly salient categorisation construct for research into music. The sedative music that has so often been used in music medicine research suggests that music without overt rhythmic structure is desirable for pain management and relaxation. The literature reviewed in this section suggests that this may be a simplistic view of the role of

rhythm in music. Rhythmicity is multi-dimensional and has multiple levels of complexity. Metre is the most salient of these and is easily perceived by music listeners with or without formal musical training. Rhythmicity has significant benefits for the use of music as a therapeutic medium, particularly in movement dysfunction disorders. Rhythmic activity models neural flow and is thus able to contribute to learning mechanisms such as comprehension of musical hierarchical structure and memory encoding. In this way music with rhythm can have therapeutic benefit as much as music without rhythm (e.g. excitative music may be as effective as sedative music). Research is needed to clarify whether music with excitative rhythms is only appropriate for movement studies, or whether it could have benefits for resting hospital-based patients, particularly through entrainment mechanisms. Music is harmonicity and rhythmicity coalesced together and though they can be viewed separately, in combination they help the listener to process musical information. The inclusion of rhythmicity as a categorisation construct is designed to extend the music medicine literature to date and to enable investigation of the particular musical constructs that contribute to audio-analgesia and to the appropriateness of musical choice in respect of pain.

## 4.5 Model of Music in Clinical Research

Within clinical domains, music is often conceived of as uni-dimensional and homogeneous. A brief survey of the wealth of musical genres and taste cultures currently in existence, indicates that this concept is perhaps over-simplified (see Diehl et al., 1983, for a listing of musical genres). There is a need for research *within* ‘music’, working to discover what musical factors facilitate audio-analgesia. For the purposes of this research and as a result of the importance of compositional constructs in the creation and perception of music, it was decided to investigate Harmonicity and Rhythmicity. This is represented two-dimensionally as a Model of Music in Clinical Research (MMCR).

This model, informed by the fields of musicology and psychology, views psychological and physiological responses to music as the result of the two key variables: harmonicity and rhythmicity. Harmonicity and rhythmicity are the building blocks of music. Research into harmonicity and rhythmicity is therefore a starting point for discussion of the influence of intra-musical factors in pain management. For the purposes of this study, harmonicity and rhythmicity are defined as follows:<sup>3</sup>

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<sup>3</sup>It is recognised from the research outlined in this Chapter that the perception of harmonicity and rhythmicity is influenced by the harmonic or rhythmic reference system held by an individual listener.

### 1. Harmonicity

Harmonicity is a global concept which reflects the consonance of music through the harmonic series. High harmonicity is represented by agreeable and stable consonant sound. Low harmonicity refers to dissonant, disagreeable and unpleasant sound that is in need of resolution (McDermott and Hauser, 2005). Together, this definition reflects a continuum concept between the high and low extremes, involving personal perception and innate understanding of music.

### 2. Rhythmicity

Rhythmicity is the maintenance of regularity and metrical quality in music. Rhythmicity can precipitate movement with the beat (e.g. clapping, clicking, dancing, tapping or swaying). High rhythmicity is highly metrical music with a regular pulse which approaches isochrony at the utmost extreme of the continuum. Low rhythmicity refers to sound with no evident regularity of metre; notes are randomly permuted as the beat is deconstructed.

These two variables are inherent in the musics of all cultures and traditions the extremes of the continua are separable into four possible combinations (see Table 4.2).

This is built through anthropogenic acculturation, intuitive knowledge and innate genetic preconditioning. It is therefore acknowledged that in selecting the musical extracts of this study, personal perceptions of harmonicity and rhythmicity were employed. Despite this, harmonicity and rhythmicity are conceptually viable phenomena which are broadly recognised and discriminated by non-musicians, as has been demonstrated in the pilot study. Efforts have been made to specify mathematically, and to computationally model harmonicity and rhythmicity (see Krumhansl, 2000; Krumhansl and Toiviainen, 2001; Parncutt, 1989; Terhardt and Seewann, 1982). Whilst these are viable approaches which may reflect musical perception, systems such as these are not mainstream methods of music selection. They are therefore not employed in this study.

Table 4.2: Possible combinations according to the Model of Music in Clinical Research

Harmonicity	Rhythmicity
+	+
–	+
–	–
+	–

Key: + = positive/high, – = negative/low

## 4.6 Rationale for Excerpt Inclusion

Using the wide variety of music available in the specialised Music Library at Edinburgh University and in the largest record store in Edinburgh (HMV), a selection of possible examples which were appropriate to the MMCR were selected by the author in conjunction with Professor Nigel Osborne. The collection of possible examples was collated according to four key criteria: (1) the music must be commercially available on CD. This was in order to ensure that the chosen music would be accessible to participants and that it could be purchased independently if so desired. (2) Where possible, the music needed to be appropriate to the taste culture of the geriatric population to be worked with in this research (following Smith, 1994). (3) The chosen music needed to be approved by both raters (trained musicians) as clearly indicative of one of the four categories of the MMCR. (4) The tracks selected should be of approximately 12–15 minutes in duration in order to be appropriate for a clinical setting.<sup>4</sup> Where tracks were shorter, they were included if they could be combined with other extracts by the same composer or from the same CD and together had a duration of approximately 12–15 minutes.

As far as possible, each excerpt was selected to demonstrate high or low harmonic-ity or rhythmicity as required by the particular category in question. It must be recognised that in order to adhere to criterion one (as above), the chosen extracts could not necessarily attain the total (0 mm or 100 mm) end-points of the scale, as commercially available music rarely encompasses the extremes and tends towards the mainstream. Extracts that achieve 100% harmonic-ity and no rhythmicity would necessitate entirely randomly permuted rhythms or no rhythm, and this is unlikely to be found in commercially available music. Likewise the opposite would be extremely rhythmic music with no element of harmonic-ity or melodic-ity—a rarity in purchasable music. Thus concerted efforts were made to ensure that the selections were clearly indicative of each category and that they could be perceived as such by non-musicians. Future work could investigate specially composed extracts with the aim of researching the extremes of harmonic-ity and rhythmicity. That was not the aim of this research: this research was intended as a clinical investigation into the influence of harmonic-ity and rhythmicity as compositional constructs on perceived pain and associated health status in an

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<sup>4</sup>The restriction of the chosen tracks to 12–15 minutes was a virtue of the time constraints existing with patients on the ward. Discussion with ward managers and senior nursing staff suggested that this would be the optimum time period for assessment: long enough for detailed research, but maintaining access to the patient for regular monitoring by clinical staff.

acute pain context.

In addition to these criteria, cultural relevance was judged to be important. Good et al. (2000) asserted the importance of including culturally relevant music as a possible choice for participants in a clinical setting. Providing the specific music of a particular cultural population is thought to set participants at ease and improve feelings of identification with the musical stimulus. Scottish music traditionally has high levels of harmonicity and rhythmicity (Collinson, 1971) and therefore it could only be included as a choice within the ++ category.

Following the compilation of a library of possible extracts, one minute samples of each extract were created for the purposes of a pilot study. A selection of 32 extracts was chosen (eight per group) and these were piloted with non-musicians to clarify their perceived levels of harmonicity and rhythmicity. This followed the procedure used by Ritossa and Rickard (2004), where musical selections are made first by musically trained experts and then are validated through a pilot study with non-musicians. This methodology has also been used in a recent study into personality-driven emotional reactions to music (Rawlings and Leow, 2008). A small pilot study was undertaken to assess whether the chosen extracts were appropriate for use in the MMCR and to identify how clearly their rhythmic and harmonic content could be perceived by non-musicians.

Ten participants were recruited via a convenience sample and were asked to listen to all one-minute excerpts. The one-minute extracts were used for the pilot study, as with the considerable number of musical choices time was too constrained to listen to all tracks in their entirety. The use of one-minute samples was in line with the methodology to be used with the participants in the acute pain research study. The patients would be selecting their music on the basis of these one-minute sound-bites heard at the Pre-admissions Clinic, therefore this methodology was applied to the pilot study. The use of one-minute extracts has been validated by Rawlings and Leow (2008) who stated that one-minute excerpts permit assessment of the reliability of participant ratings, and also facilitate some degree of generalisation beyond the specific pieces employed.

Pilot study participants were asked to rate the perceived degree of harmonicity and rhythmicity on 11-point Visual Analogue Scales (VAS). The VASs were anchored using the endpoints 'not harmonic/rhythmic at all' and 'extremely harmonic/rhythmic' (see Figure 4.5). For these scales, 0 represented no evident harmonicity/rhythmicity and 10 represented full expression of harmonicity/rhythmicity, with the midpoint (5) as



a moderate expression of the relevant construct (following Ritossa and Rickard, 2004). The three extracts that showed the poorest scores (e.g. the lowest scores for the high categories and the highest scores for the low categories) were removed. Where two extracts performed similarly in third place, a fourth excerpt was also removed. Those extracts which remained and were indicative of high or low harmonic or rhythmicity were included in the clinical research study (see Table 4.3). Where possible, the number of extracts included in each category was approximately equivalent. The ++ group retained a higher number of extracts due to the additional inclusion of a culturally relevant musical option (Scottish Harp Music) following Good et al. (2000) (see page 43 for rationale).

### Musical Extract Rating Questionnaire

**For each extract, please place an X on the line to rate the music for  
harmonicity and rhythmicity.**

**Harmonicity:** How tonal/consonant you think the harmony of the music sounds

**Rhythmicity:** How regular you think the metre (pulse) of the music is

**Extract 1**

Not harmonic at all  Extremely harmonic

Not rhythmic at all  Extremely rhythmic

**Extract 2**

Not harmonic at all  Extremely harmonic

Not rhythmic at all  Extremely rhythmic

**Extract 3**

Not harmonic at all  Extremely harmonic

Not rhythmic at all  Extremely rhythmic

**Extract 4**

Not harmonic at all  Extremely harmonic

Not rhythmic at all  Extremely rhythmic

**Extract 5**

Not harmonic at all  Extremely harmonic

Not rhythmic at all  Extremely rhythmic

Figure 4.5: Sample Sheet for Harmonicity and Rhythmicity Pilot Study

The results of the pilot study are contained in Figure 4.6 and Figure 4.7. All extracts within a single category were averaged and the differences between rhythmicity and harmonicity ratings are represented in Figure 4.6. Change scores were computed by subtracting the mean rhythmicity scores for each category from the mean harmonicity scores and the results are shown in Figure 4.7. As expected according to the model,

Table 4.3: Chosen examples applicable to the Model of Music in Clinical Research

Track No.	Artist	Group	Short-Title
1.	Ali Khan and Purna	--	Emptiness is Form
2.	Pärt	--	Festina Lente
3.	Shakuhachi	--	Akita No Sugagaki
4.	Tommy Smith	--	Into Silence
5.	Mahler	+ -	Symphony 5, Adagio Sehr Langsam
6.	Vaughan-Williams	+ -	Fantasia on a Theme by Thomas Tallis
7.	Glass	+ -	Low Symphony, Movt 1, Subterraneans
8.	Lassus	+ -	Hieremiae prophetae de Jérémie
9.	Debussy	+ -	Prélude à l'après-midi d'un faune
10.	Stravinsky	- +	Rite of Spring, Part II: Le Sacrifice
11.	Mike Oldfield	- +	Tubular Bells, Part I
12.	Keith Jarrett	- +	(If the) Misfits (Wear it)
13.	Pat Metheny	- +	Sirabhorn
14.	Miles Davis	- +	Miles Runs the Voodoo Down
15.	Vivaldi	++	Le Quattro Stagioni, La Primavera
16.	Dvořák	++	Slavonic Dances, Op.46
17.	The Rippingtons	++	Tourist in Paradise
18.	Kartsonakis and Bonar	++	Vacation in the Sun
19.	Trad. arr. Williamson	++	The Scotch Cap
20.	Stan Getz	++	Into Silence

Key: + = positive/high, - = negative/low

N.B. Examples offered are not an exhaustive list of possible musics. List as recorded on accompanying CD.

the greatest change was between harmonicity and rhythmicity in the - + ( $\bar{x} = -31.55$ ,  $\sigma = 8.07$ ) and + - ( $\bar{x} = 38.16$ ,  $\sigma = 7.38$ ) categories. The lowest levels of difference between harmonicity and rhythmicity were for the -- ( $\bar{x} = 15.16$ ,  $\sigma = 23.23$ ) and ++ ( $\bar{x} = -13.64$ ,  $\sigma = 18.03$ ) categories. Mean scores by category are shown in Table 4.4. Results show that non-musician listeners rated the extracts as reflective of harmonicity and rhythmicity. The mean scores were approximately within the top or bottom third of the VAS.

Table 4.4: Descriptive statistics showing mean and standard deviation by category from the pilot study ratings

Group	Harmonicity		Rhythmicity	
	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$
--	35.89	20.04	20.73	18.06
++	66.70	12.57	80.33	11.69
-+	29.51	9.39	61.05	22.19
+-	66.55	16.71	28.38	12.33

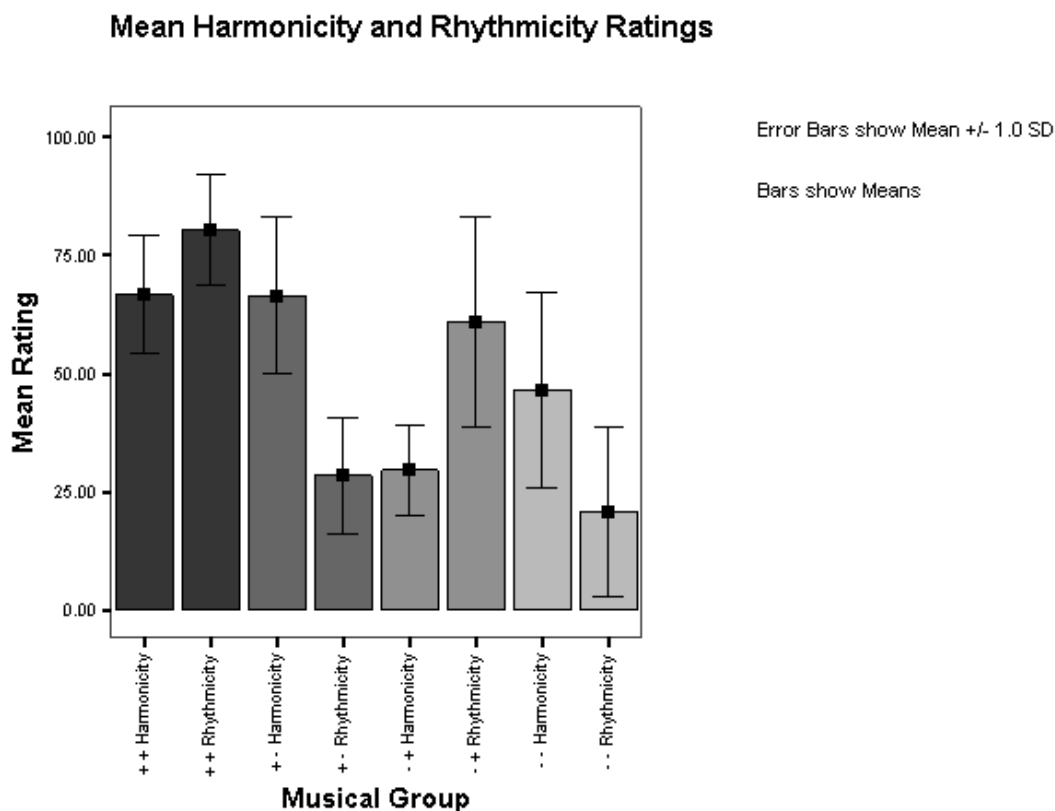


Figure 4.6: Mean ratings for all extracts by musical category according to non-musicians

Table 4.5: Selected extract combinations and lengths

Excerpt No.	Composer/Artist	Title	Excerpt Length (mins)
+ -			
1	Mahler	Symphony 5, Adagietto Sehr Langsam	11.54
2	Vaughan-Williams	Fantasia on a Theme by Thomas Tallis	14.41
3	Glass	"Low Symphony", Movement 1, Subterraneans	15.07
4	Lassus	Hieremiae Prophetae de Jérémie, Lamentatio Tertia Tertii Diei	11.42
		Missa "Congratulamini mihi": Gloria a 6	
5	Debussy	Prélude à l'après-midi d'un faune	9.02
- +			
1	Stravinsky	Rite of Spring, Part II: Le Sacrifice	18:51
2	Mike Oldfield	Tubular Bells, Part I	15.00
3	Keith Jarrett	(If the) Misfits (Wear it)	13.15
4	Pat Metheny	Sirabhorn	14.39
		Unity Village	
5	Miles Davis	Miles Runs the Voodoo Down	14.01
+ +			
1	Vivaldi	Le Quattro Stagioni, La Primavera	11.16
2	Dvořák	Slavonic Sances, Op. 46, No.s 1, 2, 4	16.18
3	The Rippingtons	Tourist in Paradise	11.47
	Jeff Golub	Drop Top	
	Klugh and James	Kari	
4	Kartsonakis and Bonar	Vacation in the Sun	12.38
		Return of the Dove	
		Ivory Passage	
5	Trad arr. Williamson	The Scotch Cap	13.44
		The Lochaben harper	
		MacGregor's Search	
		The Auld Jew	
6	Stan Getz	I Can't Get Started	11.27
--			
1	Ali Khan and Purna	Emptiness is Form	16.21
2	Pärt	Festina Lente	15.26
		Cantus in Memory of Benjamin Britten	
3	Shakuhachi	Akita No Sugagaki	12.42
		Gekko Roteki	
4	Tommy Smith	Into Silence, No.s 8, 9, 12, 15, 25	14.52

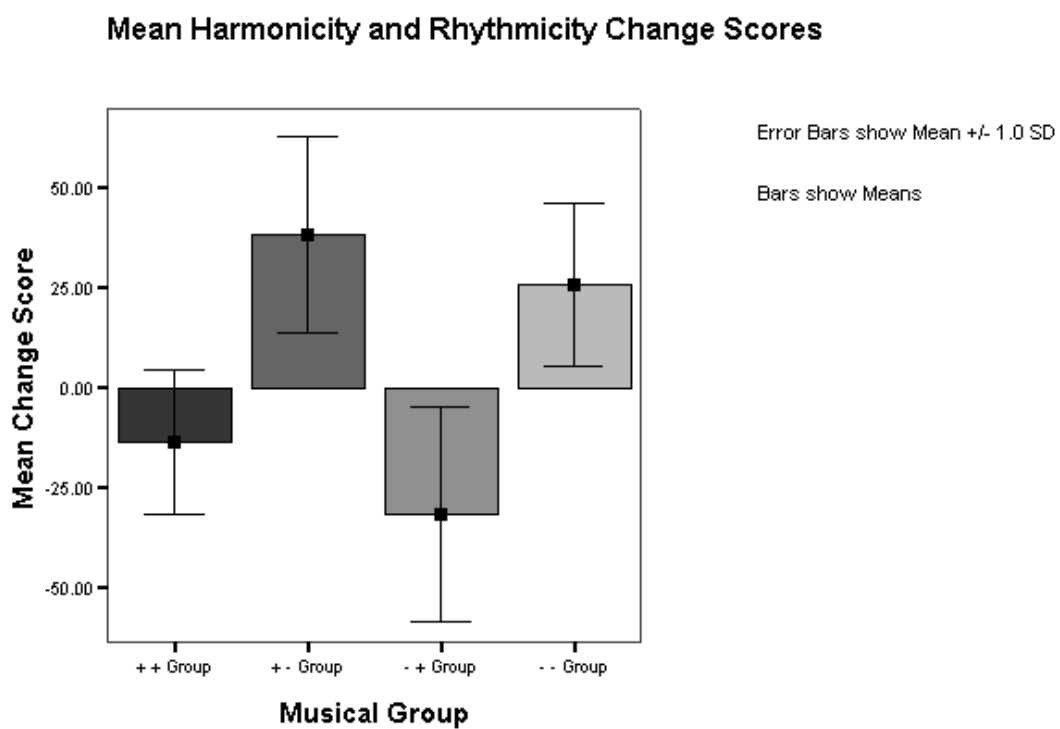


Figure 4.7: Mean change scores between ratings for all extracts by musical category according to non-musicians

Having reviewed the literature surrounding pain, osteoarthritis, categorisation, harmonicity and rhythmicity, it is now possible to formulate research questions and hypotheses in relation to the specific area to be researched in this thesis. Following the rationale embodied in the Biopsychosocial Model of Pain (Engel, 1977), it is recognised that psychological dimensions of pain are inherently connected with physiological symptoms. Consequently, psychological cognitive-coping and attention-diversion strategies do have the potential to modulate pain sensation and affect. It is therefore hypothesised that there will be a reduction in pre- to post-intervention pain scores for all participants. For control group participants this reduction will be nominal and indicative of a placebo response to the quiet relaxation intervention. For experimental participants, the emotionally-engaging, quasi-preferred music listening intervention will increase their locus of control and promote a focus external to their pain state. This will reduce their post-operative pain beyond placebo. Considering the human preference for and processing abilities in relation to harmonicity and rhythmicity, it is hypothesised that within the experimental groups, the ++ group will show the greatest reductions in their pre- to post-intervention pain scores. The -- group will show the smallest changes. This is because ++ music has high levels of consonance and regularity which may result in heightened preference for the music and an entrainment response (following Roy et al., 2008). -- music is dissonant and irregular and therefore will be least effective in changing pain states as may be negatively valenced and will not precipitate entrainment. Psychological methods of pain control, such as that of a music-listening cognitive-coping strategy, are thought to be highly affective and emotionally absorbing. This would therefore result in greater modulation of the affective components of pain. It is therefore hypothesised that affective changes in pain state will be greater than sensory changes. This difference will also be modelled between-groups, with the ++ group showing lower levels of sensory and affective pain and greater reductions in sensory and affective pain scores from pre- to post-test.

Following the work of Brook and Marshall (2001), joint replacement surgery may be categorised as both a physiological and psychological clinical stressor. Clinical stressors challenge the immune system and incite neuroendocrinological responses to the noxious stimuli. Cortisol is part of this response and is secreted in an effort to return the organism to homeostasis. As cortisol is a dynamic hormone and shows moment-to-moment changes in cortisol concentration in response to health status, it is hypothesised that there will be a reduction from pre- to post-test levels as a result of the intervention. As with pain, there will be the greatest reductions in concentration

in the + + groups and the smallest in the – – group. Participants will also be assessed for mood and functional ability in order to evaluate the impact of surgery on these dimensions and to assess whether the music listening intervention has concomitant effects on mood stability and physical condition.



# Chapter 5

## Acute Pain Research Study

### 5.1 Introduction

This study was intended as the first section of a two-phase research project into acute, clinical, post-operative pain. The research project followed patients from their Pre-admissions Clinic, through their surgery to in-patient post-operative care and pain management. Previous research into the use of music in clinical contexts (see Chapter 3) has suggested that music is a viable contributor to multi-modal pain management (see Standley, 1992, for review). This study was therefore designed to include and investigate the use of music as an integral part of the post-operative care programme offered to total knee arthroplasty patients. It was important to establish what music was most effective in producing significant and meaningful reductions in pain, and whether this may be demonstrated both physiologically and psychologically. The Model of Music in Clinical Research was therefore used for group allocation (see Chapter 3 and Table 4.2 for further detail). Clinically validated questionnaires including the Short-form McGill Pain Questionnaire and the Brief Pain Inventory were used to offer insight into the pain experience, alongside subjective Visual Ratings Scale and Numerical Ratings Scale pain surveys. Psychological state was reflected by the Profile of Mood States questionnaire. Physiological status information was collected through Salivary Cortisol concentrations. Daily observations on the success of the intervention and the well-being of the patients were reflected in qualitative data analysed through a grounded theory approach.

This research was carried out under the supervision of Professor Ian Power, Dr John Wilson and Mr Paul Gaston at the Edinburgh Royal Infirmary. All research was carried out on the orthopaedic wards at the Edinburgh Royal Infirmary and used the

surgical lists of Mr Paul Gaston and Mr Richard Burnett, consultant orthopaedic surgeons<sup>1</sup>. The post-operative anaesthesia care programme was managed through the University Department of Anaesthesia, Critical Care and Pain Medicine, guided by Dr John Wilson. The Department of Anaesthesia, Critical Care and Pain Medicine has a special interest in pain research and has developed strong relationships with the Orthopaedics Department. The selection of the musical materials for this project was facilitated by the University of Edinburgh Department of Music, supervised by Professor Nigel Osborne. This combination of disciplines and associated academic expertise provided a rich opportunity to develop multi-modal clinical care and to further clarify the interactions between music and pain.

## **5.2 Methods**

### **5.2.1 Overview**

The study was approved by NHS Lothian Regional Ethics Committee (Approval No. 06/S1101/5) and was in accordance with the Helsinki Declaration of 1975 (revised 1983). On-site permissions were granted by the Royal Infirmary of Edinburgh Research and Development Office (Ref: 2006/R/AN/06). The Wellcome Trust Clinical Research Facility conducted a Project Feasibility Review and approved the research (Ref: 06320).

### **5.2.2 Subjects**

Patients scheduled to undergo primary total knee arthroplasty in the Orthopaedics Wards, Royal Infirmary of Edinburgh, were approached regarding participation in the study. Recruitment took place over an 18-month period. Patients able to complete questionnaire-based pain and mood assessments and to tolerate wearing headphones and/or listening to music through headphones were included. Written informed consent was obtained for each patient before they were entered into the research.

#### **5.2.2.1 Exclusion criteria**

In order to avoid complications due to the elevated levels of mortality and surgical failure, patients with any history of previous total knee arthroplasty surgery in the joint

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to be replaced were not accepted; therefore primary total knee arthroplasty patients were accepted and revision total knee replacement surgeries were not. Patients were excluded if they had any contraindications to central neural blockades, were unable to give informed consent or co-operate with pain assessment, had a history of allergy to local anaesthetics, suffered from non-osteoarthritic chronic pain, or had been recruited for an alternative research study running parallel with the music study during the period of pre-admissions or hospitalisation. Patients were also excluded in their pre-assessment phase if they were unable to comprehend or independently complete the necessary questionnaires after explanation. Those patients with hearing deficits were asked to explain to what extent their hearing was affected and were asked to trial the equipment individually for quality of sound and fit. Those patients who felt that their hearing was negatively affecting their ability to listen to music were excluded.

### 5.2.3 Study Design

A randomised controlled trial design was used with elective total knee arthroplasty patients. Patients were entered into a computerised programme and a randomisation schedule was produced via [www.randomization.com](http://www.randomization.com), numbering each patient and allocating them to a group (Dallal, 2006). Both participants and investigator were blinded to the grouping procedure. Dependent on gender, patients who met the entry criteria were randomly assigned to one of five treatment groups: either the control group to receive noise-reducing headphones providing quiet relaxation (following recommendation by Cooke et al., 2005), or one of four experimental groups who received music listening. The participants in the experimental groupings were allocated according to the Model of Music in Clinical Research (MMCR) (see p.97), using the musical constructs of harmonicity and rhythmicity (four possible groups; ++, +-, -+, --).

The patients and all clinical staff were blinded as to treatment group. The researchers involved in assessments were unblinded due to group distribution: it was necessary to be able to provide and set-up the correct CD for the experimental groups or to assemble the noise-reducing headphones (given to the control group without music). The control group was provided with noise-reducing headphones in order to induce comparable isolation to the music group (following Ikonomidou et al., 2004). As all responses were physiological or self-reported by the participants, they were not subject to bias from the experimenter who remained silent during the completion of the assessment measures and therefore could not influence the outcome measures (fol-

lowing Wang et al., 2002). Recruiting was carried out by a single researcher (K.F.). To minimise inter-observer variation, the principal investigator (K.F.) carried out all preliminary assessments and all follow-up interviews. Where possible, the principal investigator was present daily for passive capture of information (see Dworkin et al., 2005). Four research nurses were trained in administering the intervention and applying the appropriate assessment measures. On occasions when the principal investigator could not be present, or when the patient load was too great to manage independently, one research nurse supported with the collection of data.

All patients underwent a detailed pain assessment at their Pre-admissions Clinic, including pain history, locations and triggers of pain, pre-operative basal cortisol concentration and mood state. Experimental participants also provided details of their musical background and preferences (see Appendix A, Figure A.1). The study was a repeated measures design, with subjects evaluated before and after the intervention across each day of their in-patient stay in hospital. Patients were assessed daily from days 1-5 post-operatively, or until day of discharge (if earlier than post-operative Day 5). Patients were assessed on the primary outcome variables of pain interference on the Brief Pain Inventory (BPI), total pain score on the Short-Form McGill Pain Questionnaire (SF-MPQ), total mood disturbance on the Profile of Mood States (POMS), and salivary cortisol concentration.

The primary outcome measures were chosen based on the recommendations of the IMMPACT task force (Dworkin et al., 2005) and pilot work by Liversidge (2005) which showed that total knee arthroplasty patients experienced a significant amount of pain in their post-operative recovery period. They were additionally derived from the studies by Watt-Watson et al. (2004), al' Absi and Petersen (2003), Leopold et al. (2003) and Hammerfald et al. (2005). Watt-Watson et al. (2004) found that patients had significantly reduced pain-related interference in activities despite no changes in pain ratings, thus the Brief Pain Inventory was included. al' Absi and Petersen (2003) showed that stress induced by increased pain altered mood and altered sensory and affective pain sensation. Hence the POMS and SF-MPQ questionnaires were included in this study. Cortisol monitoring was included Leopold et al. (following 2003) and Hammerfald et al. (2005) who showed that major total knee arthroplasty engenders change in Cortisol Concentration and that Cortisol is responsive to cognitive-coping strategies.

### 5.2.4 Materials

- **Bose QuietComfort® 2 Acoustic Noise Cancelling® Headphones**

The Acoustic Noise Cancelling® headphones utilise full-spectrum noise reduction. The headphones electronically process soundwaves and correct the difference between ‘wanted’ and ‘unwanted’ sound—a correction signal. The use of headphones for research into music and pain has been recommended by Carroll and Seers (1998) and Nilsson et al. (2003) in order to reduce environmental noise and has become standard operating practice for research in music medicine.

- **Bose Personal CD-player**

A one-person or individual portable CD-walkman was used for each patient when on the ward.

- **Cryovials**

2 mL screw-top flat-bottom cryovials were used for collection and storage of salivary cortisol samples (see [www.salimetrics.com](http://www.salimetrics.com) for purchase information).

- **Straws**

Medium-bore drinking straws were used to collect saliva samples using passive drool methodology (see Chapter 6).

- **Musical Examples**

A battery of musical examples were created according to the four possible divisions outlined in the MMCR (see Table 4.3 on page 102). All examples were of approximately 12–15 minutes in length. 12–15 minutes was deemed appropriate as short-term bursts of music listening have been proven effective in an acute pain setting (following Lee et al., 2004; McCaffrey and Good, 2000). This time period of listening was selected through interaction with nurses, doctors and consultants who considered it appropriate for demonstrating the efficacy of the treatment, yet minimising intrusion into clinical care and the daily activity that is required to successfully and efficiently operate an orthopaedic ward.

Extracts were recorded onto a Mac computer from CD at a sample rate of 16bits and 44.1kHz. This is the setting currently used for digital stereo CD quality recordings in the record industry. Where multiple tracks were used to create a combined length track, Pro Tools LE 6.9.2 was used to merge between individual

extracts and create the experimental version. To minimise any distinct boundaries between one track and the next track, short (5 second) fades were added where necessary, to fade in and fade out. All record companies and copyright holders who owned the tracks were contacted and permission to use the music for educational research purposes was granted. Each musical track was recorded onto a separate CD for ease of use and technical simplicity in a ward setting.

Four sample CDs were created for use in the Pre-admissions Clinic assessment phase. The sample CDs were created according the MMCR category (e.g. one CD for each of the ++, +-, -+ and -- categories). Each CD contained one minute excerpts from each musical example available in that category.

### 5.2.5 Pain Assessment

This consisted of three structured questionnaires:<sup>2</sup>

#### 1. Numerical Rating Scales (NRS) and Visual Rating Scales (VRS)

Two subjective assessments for pain intensity were used, thereby allowing for inter-correlation and reliability checks between measures (Anderson and Testa, 1994). These were completed for pain at rest and pain on movement. Results were expressed as a mean score for resting pain or for pain on movement, averaged across the NRS and VRS (following Anderson and Testa, 1994; Flaten et al., 2006).

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<sup>2</sup>All measures that were used followed the guidelines laid out by Dworkin et al. (2005) in the recent revision of the Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT). This aimed to standardise the assessment of pain in clinical trials by looking at all dimensions of the total pain experience. Based on the research data available at the time of writing, Dworkin et al. (2005) suggested that a raw score change of approximately 1 point or a 15–20% change in pain intensity on a VRS/NRS measure is a minimally important decrease. In generic pain assessment, a change of 2–2.7 points represents a 30–41% change and indicates treatment success and a satisfactory improvement in pain intensity. The ideal standard for VRS/NRS scores or pain assessments is therefore set at 30% for a moderately clinically important difference and 50% for a substantial improvement. Looking specifically at the BPI, Dworkin et al. (2008) recommended that a change of approximately one point on the Pain Interference Scale is approximately one standard deviation of the total scores and therefore would be a reasonable benchmark for a minimally clinically important change on the BPI. For the POMS, Dworkin et al. (2008) advocated a change of 10–15 points on the Total Mood Disturbance score of the POMS as clinically meaningful change. This equals one half of a standard deviation and one standard error of measurement. A 2–12 point change in subscale scores is also considered the benchmark of appropriate change (Haythornthwaite and Edwards, 2004). These benchmarks for change are used in this thesis as indicative of clinically meaningful differences for patients.

The NRS is an 11-point measure of pain intensity with the endpoints designated '0 = no pain' and '10 = pain as bad as you can imagine'. This is a well-established and reliable measure of subjective pain intensity (following Cleeland and Ryan, 1994; Dworkin et al., 2005).

The VRS is an appropriate measure for use in a clinical setting due to its ease and brevity of administration and scoring (Jensen et al., 1986), minimal intrusiveness (Melzack and Katz, 1999) and conceptual simplicity (Huskisson, 1983). The cut-points were of the form; none, mild, moderate and severe pain.

## 2. **The Short-Form McGill Pain Questionnaire (SF-MPQ)**

The SF-MPQ is a widely used clinical research tool (Melzack, 1983; Reading, 1989) which is a well-validated measure of pain perception (McDowell and Newell, 1990). Primary outcome measure results were expressed as a Total Pain Score (TPS) and secondary outcome measures as the subsidiary scales: sensory and affective pain

The SF-MPQ has been effective at discriminating between dimensions of pain for acute pain assessments (Dworkin et al., 2005; Rowbotham et al., 1998, see). It consists of 15 pain descriptors taken from the McGill Pain Questionnaire (long-form) which were found to be most applicable for a minimum of 33% of acute and chronic pain patients (Melzack, 1987). 15 sensory and affective pain descriptors are scored, providing an overall total score and separately summed sensory and affective subscale scores (Dworkin et al., 2005).

## 3. **Brief Pain Inventory (BPI: Short Form)**

The Brief Pain Inventory (Cleeland, 1992) is a 9-item measure of physical functioning and has been found to be highly effective in studies of patients with osteoarthritis pain (Cleeland and Ryan, 1994). Results were expressed via a single score demonstrating the Mean Pain Interference affecting daily functioning.

The BPI assesses pain over the preceding 24 hours and was therefore used on Days 1, 3 and 5 post-surgery, following Watt-Watson et al. (2004). One item from the original measure relating to 'normal work' was not considered relevant in a hospital context and was not administered. Modification of the BPI on the 'normal work' item has been employed by Watt-Watson et al. (2004) with no

change in the internal consistency of the questionnaire ( $\alpha = 0.82$  for a surgical sample (McNeill et al., 1998)). Using a disease-specific measure of physical functioning is recommended by the IMMPACT task force in chronic and acute pain clinical trials (Dworkin et al., 2005). The BPI has been validated in 25 languages (Cleeland and Ryan, 1994).

### 5.2.6 Psychological Assessment

A single measure of mood stability was used to assess the status of the patient at the time of testing.

- **Profile of Mood States (POMS)**

The POMS (McNair et al., 1971) is a factor-analytically derived 65-item measure of Total Mood Disturbance, assessing six mood states: (i) Tension—Anxiety; (ii) Depression—Dejection; (iii) Anger—Hostility; (iv) Vigour—Activity; (v) Fatigue—Inertia; and (vi) Confusion—Bewilderment. Each item is rated on a 5-point scale (0 = not at all, 4 = extremely). Results were expressed across mood states as a composite Total Mood Disturbance (TMD) score, computed by summing each of the individual scores (i to vi) and then as (secondary) subscale scores.

The POMS has been well-established in its reliability and validity for the assessment of depression and emotional distress symptoms (Kerns, 2005) and for pain (Lin et al., 2003). It assesses the three key areas of emotional functioning paramount to pain research: anger, anxiety and depression (Dworkin et al., 2005). The reliabilities (Cronbach's  $\alpha$ ) ranged from 0.75-0.95 for an outpatient sample (McNair et al., 1992).

### 5.2.7 Physiological Assessment

Cortisol was assessed in order to test the impact of the intervention on the HPA axis. Cortisol concentrations were expressed as change scores between pre- and post-operative assessment points.

1. **Cortisol**

Cortisol is an effective measure of pain and distress and may be used as a sensitive and time-dependent assessment of changes in adrenal hormones (e.g. from



heightened pain or music-associated analgesia). Results were expressed as total Salivary Cortisol Concentration at time of testing in (nmol/l).

Passive drool salivary samples were collected in cryovials (see [www.salimetrics.com](http://www.salimetrics.com) for purchase information). At the PAC and on the ward, samples were collected daily within the same one hour time period in order to negate the impact of diurnal rhythms on adrenal cortisol production (Levy, 1997). Samples were frozen at  $-40^{\circ}\text{C}$  within three hours of collection until time of analysis. As cortisol is in its unbound and free molecular state in saliva, salivary cortisol measurements effectively represent the concentration of free cortisol circulating in the body (Greenspan and Gardner, 2004). Cortisol enters the saliva through passive diffusion (Bakke et al., 2004) and is very quick to respond to changes in cortisol concentration, taking a maximum of one to two minutes (Kirschbaum and Hellhammer, 1994). Further detail regarding analysis methodologies is contained in Chapter 6.

### 5.2.8 Qualitative Data

Participants were given daily opportunities, before and after their intervention, to provide qualitative information. These opportunities were loosely semi-structured and where possible were subject-directed. The experimenter used prompts to facilitate the patient, asking open-ended questions such as “How is your pain today?”. Prompts covered five broad areas for discussion: pain, mood, sleep, physiotherapy/activity and music/relaxation, alongside any additional themes that the patients wished to talk about. In order to ensure the validity of the qualitative data, reflective notes and patient-generated themes were taken each day and at the feedback interview. These were converted into representative themes immediately afterwards. These daily themes were combined with comments from the feedback interview, and sorted into categories by constant comparison through thematic content analysis.

### 5.2.9 Analgesia

- **Patient-controlled Analgesia Usage (PCA)**

This was monitored at the first 24-hours post-operatively. PCA usage has been considered a reliable outcome measure and an important supplemental measure of the efficacy of the treatment being assessed (Chrubasik et al., 2003; Dworkin

et al., 2005). The PCA device was removed from patients before the first intervention session, therefore PCA usage is included to assess comparability between groups and could not be affected by the intervention.

### **5.2.10 Peri-operative Care: Anaesthetic Regime**

No pre-medication was given. Any prescribed analgesics were continued up until the time of surgery. Both groups received combined spinal, femoral and sciatic anaesthesia and intravenous sedation. All anaesthesia and peri-operative care was undertaken by clinical staff who were alerted to the anaesthetic regimen but who were completely blinded to the grouping of the patient.

#### **5.2.10.1 Theatre**

- **Midazolam**

2mg IV

- **Femoral Nerve Block**

15mls 0.375% bupivacaine using 50mm stimuplex needle to a threshold of less than 50mA. The femoral nerve block has been found to be more effective than general anaesthetic at improving gait, pain, recovery and functional ability in total knee and total hip arthroplasty patients (Peters et al., 2006).

- **Sciatic Nerve Block**

25mls 0.375% bupivacaine using 100mm stimuplex needle to a threshold of less than 50mA

- **Spinal Anaesthesia**

3.0mls 0.5% plain bupivacaine using a 24G Sprotte needle.

- **Ondansetron**

4mg IV Sedation using a propofol infusion. Fluids and pressors as required.

#### **5.2.10.2 Post-operative Analgesia**

- **IV Fluids and Morphine PCA**

Overnight 1mg bolus with 5 minute lock-out.

- **Paracetamol**

1g four times per day.

- NSAID
- **Oxycontin**  
10mg twice per day starting morning of Day 1 for 4 doses.
- **Oxynorm**  
5-10mg 1 hourly as required
- **Cyclizine and Ondansetron Antiemetics**  
As required

### 5.2.11 Statistics: Design and Analysis

A small pilot study looking at current subjective pain scores experienced by knee replacement patients in the Royal Infirmary of Edinburgh was conducted (Liversidge, 2005). Mean total pain scores for patients experiencing no intervention registered at 20 ( $n = 25$ ,  $\sigma = 10$ ). A 30% reduction in pain scores was the boundary for a clinically relevant improvement. For a power of 80%, an estimated sample size of 34 per group was needed (Power = 0.8;  $\alpha = 0.05$ ).<sup>3</sup> Statistics were carried out using SPSS for Windows v.14. Descriptive statistics are presented using mean ( $\bar{x}$ ) and standard deviation ( $\sigma$ ). Other measures were compared using Analysis of Variance (ANOVA) and chi-square tests (following al' Absi and Petersen, 2003; Watt-Watson et al., 2004). Line graphs and bar charts are presented to represent data graphically and error bars pertain to one standard error either side of the mean. Salivary cortisol concentrations were measured in nmol/l.

Information gained from the background and medical history questionnaire at the Pre-admissions Clinic is presented through percentages %, numbers of patients ( $n$ ), mean and standard deviations which are tabulated as descriptive statistics. Intervention and control group data were compared to assess the comparability of groups at baseline using chi-square analysis for discrete level data and one-way univariate analysis of variance (ANOVA) for continuous level data. Background information included baseline VRS/NRS, Mean Pain Interference, Total Pain Score, Total Mood Disturbance and Cortisol. Baseline PCA-usage data from post-operative Days 0 and 1 (pre-intervention) was also analysed through a one-way ANOVA.

For the primary outcome measures, one-way between-group ANOVAs (Group Allocation; between-subjects, 5 levels; control, ++, +-, -+, --) were first computed

$${}^3n > 2 \left\{ \frac{(z_{\alpha} + z_{\beta})\sigma}{d} \right\}^2 \text{ becomes } n > 2 \left\{ \frac{(1.645 + 0.84)10}{6} \right\}^2 = 34.31 \text{ Following Armitage et al. (2002).}$$

on all days of data (Day of Testing; within-subjects, 5 levels; post-operative days 1–5) to determine the effect of Group on the outcome. Following this, repeated-measures ANOVAs (RM-ANOVAs) were performed to determine the impact of Group (Group Allocation; between-subjects, 5 levels) on Day of Testing (within-subjects, 3-levels; post-operative days 1–3) and Time of Testing (within-subjects, 2 levels; pre- and post-test) on Mean Pain Interference, Total Pain Score, Total Mood Disturbance and Cortisol. Due to the early discharge of some participants (47.96% of patients had been discharged by Day 4 and 69.39% by Day 5, see page 128), it was not possible to compute an appropriately powerful repeated-measures ANOVA to display the changes in a particular variable over the full course of the study, from Pre-admissions Clinic to Day 5. In order to avoid a significant discharge-related loss of power, RM-ANOVAs were only computed using data from days 1–3, when only a small percentage of patients had been discharged (15.31%) and the test would still have a high level of power. For significant ANOVAs with all outcomes, post hoc comparisons using Bonferroni's adjustment were used to determine the source of the difference. Secondary outcome variables (VRS/NRS, BPI, SF-MPQ and POMS sub-dimensions) were analysed the same way. Where patients were discharged early or withdrew from the study, all complete days of data were used in the analysis.

## 5.3 Procedure

### 5.3.1 Pre-operative Assessment

Ethical approval for the study was granted by the ethics committee at NHS Lothian and the Research and Development Department of Edinburgh Royal Infirmary. Patients who were scheduled for primary total knee arthroplasty were identified from the hospital waiting lists. Following this, participants eligible for the study (see exclusion criteria above) were approached by letter approximately two weeks before their attendance at their Pre-admissions Clinic (PAC). The letter included a brief outline of the study and a patient information sheet. The information sheet indicated that the study was for research into 'Relaxation and Post-operative Pain'<sup>4</sup> and outlined the rationale for the study, the extent of patient involvement, the procedures and possible methods of relaxation, and hypothesised results.

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<sup>4</sup>The study was deliberately termed a "Relaxation and Post-operative Pain Research Study" to blind participants to grouping factors (i.e. music vs. silence).

Upon arrival at the Pre-admissions Clinic, all participants were approached by the principal investigator, the details of the study were clearly outlined and patients were asked whether they wished to participate. If the patient wished to continue, informed consent was taken and it was countersigned by the chief investigator. Participants then undertook a 20-minute, preliminary assessment in the course of their Pre-admissions Clinic. Participants were asked to provide basic demographic information: superficial information concerning their musical background (exposure to Formal Instrumental Musical Tuition (FIMT), favourite musical genres, and current listening habits), a standard medical history, and a detailed pain history. A Salivary Cortisol sample was taken, and participants were asked to complete the SF-MPQ, BPI, POMS, VRS and NRS measures. The scores from these questionnaires and physiological measures were taken as baseline scores indicative of pre-operative pain, mood stability levels and physiological well-being.

After the baseline assessments and as appropriate to their grouping, participants were given the opportunity to listen to a number of one minute musical excerpts from the sample CD (see Table 4.3) and to select their favourite. Their chosen extract was later used on the ward post-surgery in its entirety (approximately 15 minutes). During the course of their musical selection, participants used the headphones and CD-player as they later did on the ward. Participants in the control group were not exposed to music, but were told that their relaxation would be quiet relaxation, providing a respite from normal hospital sounds (e.g. 'silence'). They were shown the specialist noise-reducing headphones and were encouraged to try them on. All groups were informed that they would receive standard care in addition to the appropriate intervention. All patients were requested to refrain from listening to their own music after their operation. Patients were advised that they could withdraw from the study at any time. Patients' General Practitioners were informed by letter if a patient provided informed consent.

### **5.3.2 Post-operative Assessment**

On the first day of assessment, participants were met on the ward by the researcher.<sup>5</sup> Patients were seen consistently either from 12.30pm–2.30pm or from 4pm–5pm on the ward in order to minimise any interruption or inconvenience. Participants were given with a small folder containing a booklet which took them through all necessary

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<sup>5</sup>This constitutes Day 1. The day of surgery being Day 0. Patients were assessed for a maximum of five days post-operatively; Days 1–5.

Table 5.1: Groupings according to the Model of Music in Clinical Research

	<b>Harmonicity</b>	<b>Rhythmicity</b>
A	+	+
B	--	+
C	+	--
D	--	--
E	Control (Noise-reduction)	

Key: + = positive/high, - = negative/low

questionnaires and measures. Upon waking each morning and before bed each evening (Days 1–5), participants completed the VRS and NRS. These questionnaires were self-administered, with reminders from nursing staff and the researcher.

Each afternoon patients were visited by the researcher or a research nurse and the measurements for that day were taken. Firstly patients were asked about their well-being, mood, pain, activity and sleep that day, providing qualitative data. Subsequently, before the music/quiet intervention, SF-MPQ scores and Cortisol concentration were assessed (see page 6.3.0.1 for description of salivary cortisol collection procedure). On Days 1, 3 and 5 (as appropriate) of in-patient care, patients also completed the BPI and POMS before the intervention. After completing the questionnaire measures and physiological assessment, the music/control equipment was set up and given to the patient for use. Patients did not need to work the equipment and no technological knowledge was required. The volume button on the CD-player was shown to the music participants and was set at an appropriate level which they could alter if they wished. During the 15 minute period of music listening or relaxation, participants were advised that they should find a postural position that was comfortable for the duration of the listening. They were asked, as far as possible, to refrain from doing any other activity external to the music listening. Participants were asked to relax, to listen and focus on the music or relaxation. During this time, the curtain was drawn around the patient's bed for privacy and the patient was not disturbed unless there was a specific reason, either due to a request from the patient or in order to administer urgent clinical care requirements. The researcher left the curtained area for 15 minutes and ensured that the participant was not interrupted.

Upon completion of the intervention, Salivary Cortisol Concentration was measured and SF-MPQ data was again collected. The patient was then given an opportu-

nity to comment qualitatively on their music, mood, pain or other thoughts. Qualitative and observational data was recorded daily and a record was kept of analgesia and physiotherapy improvement.<sup>6</sup> On the final day of their hospital stay, participants completed a semi-structured feedback interview with the researcher, detailing pain changes, mood alterations, sleep patterns, perceived benefits and drawbacks, and suggestions for further research. All completed, full days of data were included in the analysis. Where patients withdrew before they had completed the study, they were asked whether they were willing to complete the feedback questionnaire and their results up to the day of withdrawal were used in the final analysis.

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<sup>6</sup>Standard improvement suggests that on Day 1 patients are generally bed-based with limited movement, on Days 2–3 patients progress to walking short-distances on a zimmer frame, and on Days 3–4 patients use two walking sticks for mobility. Patients also complete daily physiotherapy exercises such as bending, lifting, lateral movement and are generally released from in-patient care when they can attain independence on walking sticks and a knee bend of 70°.

# Chapter 6

## Cortisol

### 6.1 Introduction

This research was carried out under the supervision of Dr Emad al-Dujaili of Queen Margaret University. The analysis of the cortisol concentrations was conducted at the School of Health Sciences in the Nutrition, Dietetics and Biological Science laboratories of Queen Margaret University. The analysis was carried out using Salimetrics Cortisol ELISA kits purchased with the aid of funding from the Edinburgh Development Fund. The methodology employed was that of a competitive immunoassay technique.

An Enzyme-Linked ImmunoSorbent Assay (ELISA) is based on the principle of a competition between a Cortisol Enzyme Conjugate provided by the ELISA kit, and a cortisol sample provided by the patient. The anti-cortisol coated microtitre plate is a research plate coated with a monoclonal antibody which seeks only to bind with cortisol. This specificity is important as it means that only the antigen under investigation can bind with the plate, meaning that the results remain pure. Cortisol is this antigen: as the cortisol sample is added first, it binds strongly to the antibody-coated wells. Subsequently, the cortisol enzyme conjugate competes with the cortisol standard (in standard curve wells) or cortisol in patient sample wells for binding with the antibody coated on the plate. The more cortisol that is concentrated in the clinical sample, the less the availability of the antibody for the enzyme conjugate to bind with and the lower the colour of the plate. Conversely, the lower the cortisol concentration in the sample, the more that the cortisol enzyme conjugate is able to bind with the plate, creating a brighter colour. The plate is extremely sensitive and has a high discriminatory ability and is able to detect very small amounts of cortisol at a power of  $10^{-9}$  of a gram of cor-



tisol. When the plate is read, light is passed through the microtitre wells and according to the colour of the well, it is possible to measure the amount of cortisol concentration provided by the sample after constructing the cortisol ELISA standard curve using the in-built software of the ELISA reader.

### **6.1.1 Validation of Cortisol ELISAs**

The Salimetrics cortisol ELISA kit that was used in this research has undergone rigorous optimisation and validation assessment and is approved by the United States Food and Drug Administration (FDA; ref: 862.1205). The quantities of antibody and enzymes to be used have been optimised, as has the appropriate incubation time for the ELISA analysis. The stability of reagents has been assessed and the goodness of fit of the ELISA-generated results have been assessed (Salimetrics, 2006). The kit has been validated for accuracy, parallelism, imprecision/error and correlational studies. Accuracy was assessed through a recovery experiment, in which known quantities of cortisol were analysed through the kit and the accuracy of the recovered results were compared. Parallelism was assessed by dilution of the samples, enabling the assessment of high concentrations through to low concentrations and referencing this against the standard curve. Imprecision/error were assessed through a comparison between the quality control samples provided with the kit. They were repeatedly assayed inter- and intra-assay to establish whether there was any calculable error profile. Finally the kit was validated through correlational studies and was referenced against other methods of analysis. It was found to be comparable with chromatographic methodologies.

## **6.2 Methods**

### **6.2.1 Apparatus**

#### **6.2.1.1 Cortisol Reagents**

- **Salivary ER Cortisol EIA Kit**

An ELISA kit for research-based salivary cortisol analysis (Salimetrics, 2006).

- **Salivary Cortisol Control Set**

1 mL low and high control sets for research-based salivary cortisol analysis.

- **Anti-Cortisol Coated Plate**

A 96-well microtitre plate pre-coated with monoclonal anti-cortisol antibodies

- **Cortisol Standards**

Six standards, containing cortisol concentrations of 3.000  $\mu\text{g}$ , 1.000  $\mu\text{g/dL}$ , 0.333  $\mu\text{g/dL}$ , 0.1111  $\mu\text{g/dL}$ , 0.037  $\mu\text{g/dL}$  and 0.012  $\mu\text{g/dL}$ , in a synthetic saliva matrix with a non-mercury preservative.

- **Wash Buffer**

100 mL of a 10X phosphate buffered solution containing detergents and a non-mercury preservative at pH 7.4. This was diluted with de-ionised, sterilised water and rested at room temperature before using.

- **Assay Diluent**

63 mL of a phosphate-buffered solution, containing a pH indicator and a non-mercury preservative.

- **Enzyme Conjugate**

50  $\mu\text{L}$  of a solution of cortisol labelled with horseradish peroxidase. This was used in a diluted form with the assay diluent.

- **Tetramethylbenzidine (TMB)**

25 mL of a non-toxic solution.

- **Stop Solution**

12.5 mL of a solution of sulphuric acid. This was provided in powdered form and reconstituted with 12.5 mL of de-ionised, sterilised water before use.

### 6.2.1.2 Cortisol Analysis Materials

- **Precision Pipette**

For volumes of 15  $\mu\text{L}$  and 25  $\mu\text{L}$ .

- **Precision Multichannel Pipette**

For 50  $\mu\text{L}$  and 200  $\mu\text{L}$  delivery.

- **Vortex**

Used to mix standards and stop solution.

- **Plate Rotator**

Used to settle the plate and remove trapped air bubbles.

- **Dymex MRX ELISA Plate Reader**  
Passes light through the plate and analyses the concentration of the samples.
- **De-ionised Water**
- **Reagent Reservoirs**
- **Disposable Tube**
- **Pipette Tips**
- **Serological Pipette**  
To deliver up to 24 mL

### 6.2.2 Design

The design of the cortisol analysis research was the same as that of the clinical research study. All patients, both experimental and control were briefed on the salivary cortisol sampling methodology at their Pre-admissions Clinic and provided a sample if informed consent was given and they were physically able and willing. Following their surgery the participants then provided a saliva sample before and after the intervention period. Patients were exempted from providing a sample if it induced significant nausea or if they had recently experienced a bout of vomiting.

## 6.3 Procedure

### 6.3.0.1 Cortisol Collection

Patients were provided with a glass of water and were asked to rinse their mouth with water, swilling and then spitting the water into a collection bowl. This was repeated three times. A small section (a quarter of a stick) of sugar-free chewing gum was then given to the patient to chew to stimulate saliva production. After a period of approximately one minute the gum was removed and the first mouthful of saliva was discarded. Using a short straw (approximately three inches in length) placed in a cryovial, the participant was asked to place their lips around the straw, to allow saliva to pool *in* the mouth and to push this down the straw. This process takes approximately 2–3 minutes in total. The procedure is termed ‘passive drool’ methodology. Upon collection, samples were frozen within four hours of collection at  $-40^{\circ}\text{C}$  to precipitate the mucins.

### 6.3.0.2 Cortisol Analysis

All reagents were first brought to room temperature and the microtitre plate was removed from its foil packaging and covered. 24 mL was pipetted into a disposable tube and set aside. 25  $\mu\text{L}$  of standards, controls and saliva samples were pipetted to appropriate wells along with 25  $\mu\text{L}$  of assay diluent to serve as zero (Salimetrics, 2006). These were all pipetted in duplicate for reliability cross-referencing. Cortisol enzyme conjugate was then diluted by adding 15  $\mu\text{L}$  of conjugate to the diluent. This was mixed using a vortex and 200  $\mu\text{L}$  was added to each well using a multi-channel pipette. The plate was mixed on a plate rotator for five minutes at 500 RPM and incubated in the dark for 55 minutes. After incubation, the plate was washed using the wash buffer, pipetting 200  $\mu\text{L}$  into each well using a multi-channel pipette. This was then discarded and the wash was repeated four times, counter-balancing each time (e.g. pipetting from 1–12 and then in reverse, 12–1, with the next wash). After each wash the plate was thoroughly blotted dry on paper towels before being turned upright. When dry, 200  $\mu\text{L}$  of TMB solution was pipetted into each well. This was mixed on the plate rotator for a further 5 minutes and incubated in the dark for 25 minutes. After 25 minutes, when colour was shown, 50  $\mu\text{L}$  of stop solution was added with a multi-channel pipette. The stopped plate was mixed for a further five minutes on the plate rotator and read in the plate reader at 450nm. The average optical density (OD) was computed for all duplicate wells and the concentration of controls and samples was interpolated using a 4-parameter sigmoid spline curve fit. All samples from a single participant were analysed at the same time with the same kit, using cortisol analysis kits purchased from [www.salimetrics.com](http://www.salimetrics.com).

# Chapter 7

## Acute Pain Results

### 7.1 Analysis and Statistics

Data is analysed first in light of the primary outcome measures of Mean Pain Interference, Total Pain Score, Total Mood Disturbance and Cortisol Concentration (see Section 7.9). Results are represented graphically and descriptive statistics for these primary outcome measures are tabulated. Following this, the secondary outcome measures which include the sub-scales of the Brief Pain Inventory, Short-form McGill Pain Questionnaire, Profile of Mood States and VRS/NRS measures are analysed. Where appropriate, descriptive statistics showing means and standard deviations are displayed within this Chapter. There were no adverse events which were attributable to the intervention.

After the quantitative analysis has been outlined, the data from the qualitative feedback will be portrayed in Section 7.11. This is defined in the context of four broad thematic-reponse categories: physiological, psychological, methodological and musiological. Within the first three categories, responses are separated by non-intervention-related and intervention-specific comments.

### 7.2 Data Response and Length of Stay

The results displayed in this chapter reflect the data available and collected from those patients who were able/available for their research sessions. Table 7.1 displays the discharge and withdrawal points of all patients in the research study. All full days of testing are included in the analysis.

Six patients were unable to complete their questionnaire and research on Day 1

Table 7.1: Stage of Exit from the Clinical Research Study

Day of Testing	Withdrew	Missed	Discharged	Cumulative Total Exiting Research
Day 1	0	6	0	0
Day 2	3	1	0	3 (3.06%)
Day 3	2	0	10	15 (15.31%)
Day 4	2	0	30	47 (47.96%)
Day 5	0	0	21	68 (69.39%)

due to severe post-anaesthetic nausea but did not wish to withdraw from the study. All had improved sufficiently by Day 2 to continue with their involvement in the research. On Day 2 one patient was missed from the research due to their attendance at the x-ray clinic and unavailability for the research session during the specified times. In the course of the research project, seven patients in total withdrew from the research (see CONSORT diagram on page 131 for reasons for withdrawal). These patients were lost to follow-up. Patients who were discharged from the research were sent home after significant improvement in their operated knee and after an assessment by a physiotherapist who was satisfied with their progress and with their functional abilities. Few ( $n = 30$ ) patients remained in hospital for the full five days of assessment. As a result of the number of patients discharged before completing their full five days of study, the results in this chapter firstly provide an overview of responses across the five days of testing and then look in more depth at the data using only the results from post-operative Days 1–3.

### 7.2.1 Normality, Homogeneity and Internal Consistency

Primary outcome variables and physiological data was tested for normal distribution using the Kolmogorov-Smirnov test. No outcome variables showed significant results ( $p > .05$ ), therefore all data was normally distributed.

Mauchly's test of sphericity was not significant for any of the univariate or repeated-measures ANOVAs computed, therefore sphericity was assumed and the homogeneity of variance assumption was not violated.

Internal consistency for the study was calculated using Cronbach's alpha. According to Kline (1993, 2000), the minimum acceptable criterion for internal consistency is Cronbach's  $\alpha = 0.79$ . All measures used in this study attained this level. Results

for the primary outcome measures showed that for the BPI internal consistency was good, with Cronbach's alpha registering at  $\alpha = 0.79$  which is similar to the results for surgical patients reported in McNeill et al. (1998). For the SF-MPQ, internal consistency was high at  $\alpha = 0.82$ , equivalent to other studies with pain populations (Wright et al., 2001) and slightly above the generic levels cited in Melzack ( $\alpha = 0.78$ ; 1987). The POMS questionnaire showed internal consistency of  $\alpha = 0.79$  which is within the normal range of a patient sample for the POMS questionnaire (McNair et al., 1992).

### 7.3 Recruitment Characteristics

In the course of the 18-month recruitment period, a total of 122 patients (54 Males and 68 Females) were identified through standard hospital lists. All subjects were the patients of two consultant orthopaedic surgeons at the New Royal Infirmary in Edinburgh (see page 108). Of the 122 patients approached, 98 (80.33%) agreed to take part and were recruited for the study and 24 patients (19.67%) did not proceed with consent. The given reasons for non-involvement are graphically represented in the Consolidated Standards of Reporting Trials (CONSORT) Diagram in Figure 7.1.

Of the 98 patients who gave informed consent, 40.8% were male ( $n = 40$ ) and 59.2% ( $n = 58$ ) were female. 51% ( $n = 50$ ) of patients were scheduled for primary total knee arthroplasty on their left knee and 49% ( $n = 48$ ) were scheduled for surgery on their right knee. Mean age of participants was 68.07 years ( $\sigma = 8.03$ , range 49–84 years). Men and women were comparable in age at the time of surgery (Males:  $\bar{x} = 68$ ,  $\sigma = 7.96$ , range 49–84 years; Females:  $\bar{x} = 68.12$ ,  $\sigma = 8.14$ , range 51–83 years). All participants were randomly allocated into five groups; four experimental groups and one control group. The control group consisted of 20 patients (20.4%; 8 males and 12 females), four of whom did not complete the full course of the study (4.08%, 1 male and 3 females). See Figure 7.1 diagram for a flow diagram of group distribution and given reasons for early withdrawal. The '+ +' group was made up of 18 patients (18.4%; 7 males and 11 females) and 3 participants withdrew early (3.06%, 3 females). The '- +' group consisted of 18 patients (18.4%; 8 males and 10 females) and all completed the study. The '+ -' group was of 21 patients (21.4%; 8 males and 13 females), of whom 1 patient did not complete the study (1.02%, 1 female). The '- -' group was 21 patients (21.4%; 9 males and 12 females), with 3 participants who withdrew (3.06%, 1 male and 2 females). 11 patients in total did not complete the full course of the study (11.22%, 9 females and 2 males).

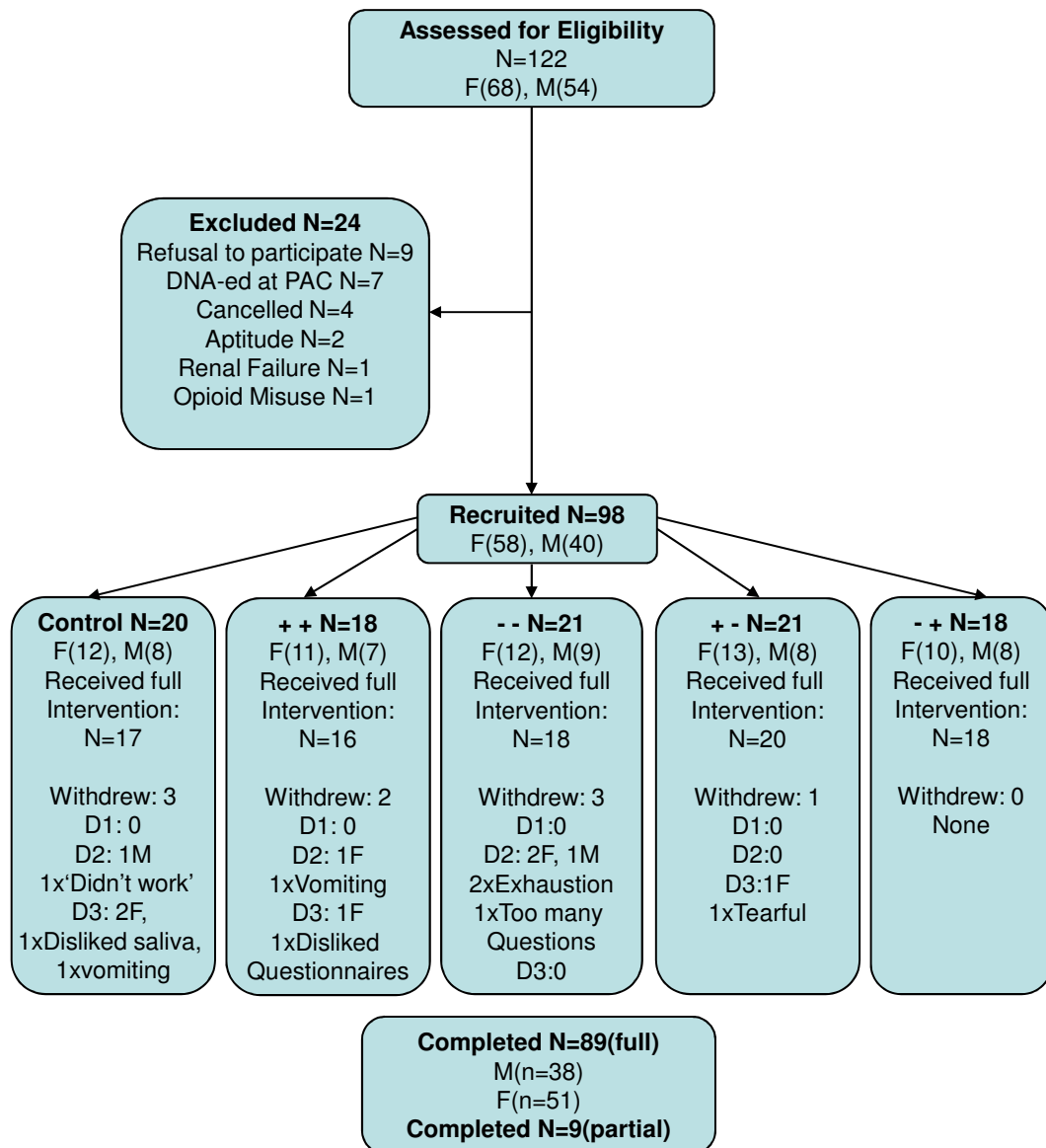


Figure 7.1: CONSORT diagram showing the flow of participants throughout the study, groupings, gender distributions and reasons for withdrawals



Table 7.2: Descriptive statistics demonstrating age of participants and chronicity of pain according to group distribution.

Group	No. of Participants		Age (years)		Chronicity (years)	
	<i>n</i>	%	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$
Control	20	20.4	68.50	9.04	15.4	15.25
++	18	18.4	68.78	8.78	8.50	7.62
+ -	21	21.4	67.67	7.43	8.26	5.95
- +	18	18.4	68.83	8.99	8.00	5.61
--	21	21.4	66.81	6.52	10.86	10.66

## 7.4 Group Distribution

In order to investigate the stability, comparability and equivalence between groups, a series of ANOVAs were computed.

### 7.4.1 Previous Surgery and Chronicity

62.2% ( $n = 61$ ) of patients were undergoing arthroplasty surgery for the first time and 37.8% ( $n = 37$ ) of patients had previously had knee replacement surgery on their other side. A Pearson's chi-square test was computed and showed that there was no relationship between previous knee replacement surgery and the Group Allocation of the participant ( $\chi^2 = 2.190, df = 4, NS$ ). A between-subjects ANOVA was computed for chronicity of pain. There was no significant effect of years of pain ( $F_{(4,91)} = 1.951, NS$ ) indicating that there was no significant difference between groups in the number of years that the participants had experienced knee pain before undergoing surgery. A one-way univariate between-groups ANOVA investigating the relationship between Group and Age of patients showed that there was no significant effect of Age ( $F_{(4,93)} = .225, NS$ ).

### 7.4.2 Mental Health and Group Distribution

Four Pearson's chi-square tests were conducted to look at the relationship between Group Distribution and Anxiety, Depression, Anxiety/Depression Medication use and Pain Medication use. There was no relationship between suffering from feelings of

Depression and Group Allocation ( $\chi^2 = 1.129, df = 4, NS$ ). The analysis for feelings of anxiety, for Anxiety/depression Medication usage and for pain medication usage showed that 5 cells had expected count of less than 5, so an exact significance test was selected for Pearson's chi-square. There was no relationship between Group Allocation and Anxiety ( $\chi^2 = 3.560, df = 4, \text{exact } p = NS$ ), Group Allocation and Anxiety/depression Medication Usage ( $\chi^2 = .834, df = 4, \text{exact } p = NS$ ) or Group Allocation and Pain Medication usage ( $\chi^2 = .721, df = 4, \text{exact } p = NS$ ).<sup>1</sup>

## 7.5 Pre-admissions Clinic Data

### 7.5.1 Subjective Ratings: VRS/NRS

Two arithmetic means were calculated for the ratings scales, one detailing the intensity of Pain at Rest, and the second showing the intensity of Pain at Movement (knee bending) (following Flaten et al., 2006). Two univariate ANOVAs were computed on data gathered at the Pre-admissions Clinic, using the between-subjects factor of Group (5 levels, according to the MMCR). There was no significant difference between groups in Resting Pain ( $F_{(4,93)} = .855, NS$ ) or Pain on Movement ( $F_{(4,93)} = 1.114, NS$ ), indicating that groups were comparable in their baseline pre-surgical pain scores. See Table 7.3 for descriptive statistics.

<sup>1</sup>Pain medication usage was defined as a categorical response to the question "Do you currently take any form of pain medication?"

Table 7.3: Descriptive statistics showing means and standard deviations for VRS/NRS pain scores at rest and on movement at the Pre-admissions Clinic

Group	Resting Pain			Articulation Pain		
	<i>n</i>	$\bar{x}$	$\sigma$	<i>n</i>	$\bar{x}$	$\sigma$
Control	20	54.93	25.04	20	71.83	19.49
++	18	44.42	28.13	18	65.54	22.75
+−	21	43.94	26.38	21	59.84	22.31
−+	18	38.69	26.09	18	64.97	20.20
−−	21	47.00	33.89	21	70.67	18.93
<b>Total</b>	98	45.96	28.09	98	66.60	20.81

## 7.5.2 Brief Pain Inventory

To look firstly at the primary outcome measure of Pain Interference on the Brief Pain Inventory,<sup>2</sup> four one-way ANOVAs were computed to investigate the impact of Group. There was no significant difference between groups at the Pre-admissions Clinic ( $F_{(4,93)} = 1.224, NS$ ).

## 7.5.3 Short-form McGill Pain Questionnaire

To establish the reliability of group distribution at the Pre-admissions Clinic, four one-way ANOVAs were computed, using the between-subjects factor of Group (5 levels; according to the MMCR). There was no significant effect of Group on the Total Pain Score ( $F_{(4,93)} = .269, NS$ ), Sensory dimension of pain ( $F_{(4,93)} = .292, NS$ ), Affective dimension of pain ( $F_{(4,97)} = .243, NS$ ) or VAS pain ratings ( $F_{(4,97)} = .755, NS$ ).

## 7.5.4 Profile of Mood States

To assess the variance within the groups at their Pre-admissions Clinic, a one-way between-subjects ANOVA was computed using the between-subjects factor of Group Allocation on Total Mood Disturbance score (TMD). There was no significant effect of Group on Total Mood Disturbance ( $F_{(4,97)} = 2.078, NS$ ).

## 7.5.5 Physiological Measures

The physiological data generated from salivary cortisol sampling was analysed. A one-way between-subjects ANOVA was computed on the results from the baseline cortisol sample taken at the Pre-admissions Clinic, using the between subjects factor of Group Allocation. There was no significant effect of Cortisol Concentration, indicating that the sample concentrations were comparable between all groups pre-operatively ( $F_{(4,62)} = .207, NS$ ).<sup>3</sup>

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<sup>2</sup>Question 9 of section D was excluded from analysis as it necessitated information regarding 'normal work' (following Watt-Watson et al., 2004). This was not appropriate for the post-test setting as hospitalised participants do not experience daily 'normal work'.

<sup>3</sup>24 patients (24.5%) of patients were unhappy to provide saliva samples or found it too difficult to generate saliva post-operatively, therefore no samples were available for these patients and they were excluded from the cortisol analysis (see page 150 for reasons given for sample refusal).

Table 7.4: Descriptive statistics showing Pre-admissions Clinic baseline physiological data

	Cortisol (nmol/l)	
	M	SD
Control	11.65	16.14
++	10.82	13.49
+-	10.70	8.18
-+	14.64	17.91
--	10.89	7.79

## 7.6 Analgesia Baseline Data

### 7.6.1 Patient-controlled Analgesia

Two one-way ANOVAs were computed on the amount of morphine self-administered by patients on their Patient-controlled Analgesia device (PCA), using the between-subjects factor of Group Allocation (5 levels; according to the MMCR). There was no significant main effect of Group on PCA usage on the day of surgery (Day 0) ( $F_{(4,56)} = .177, NS$ ) or on post-operative Day 1 ( $F_{(4,56)} = 1.092, NS$ ). The groups were therefore comparable in the amount of PCA rescue analgesia that they required post-surgery. See Table 7.5 for descriptive statistics.

Table 7.5: Descriptive statistics showing Patient-controlled Analgesia usage for Group, Anxiety and Depression

Group	PCA Usage on Day 0 (ml)			PCA Usage on Day 1 (ml)	
	n	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$
Control	11	16.73	17.73	27.55	22.25
++	10	17.60	17.60	31.30	24.58
+-	13	16.77	16.77	27.00	16.74
-+	15	14.67	14.67	18.33	25.77
--	12	13.17	13.17	16.58	11.97
Total	61	15.67	15.67	23.62	21.03

## 7.7 Medical History and Patient Background

### 7.7.1 Incidence and Experience of Arthritis

All participants suffered from arthritic pain and radiographic arthritis and had experienced knee problems for a mean of 10.31 years ( $\sigma = 10.06$ , range 1–50 years). 90.82% ( $n = 89$ ) of participants felt that their knee injury or knee problem was significantly affecting their life, whereas 9.18% ( $n = 9$ ) felt that their life remained unaffected by their condition. When asked how their knee condition affected their lives, 57.14% ( $n = 56$ ) of participants stated that they had problems with walking and 41.84% ( $n = 41$ ) found that stairs were difficult. The location of the pain experienced by patients pre-operatively was most prominently located in the front of the knee (53.06% of patients,  $n = 52$ ) and on the inside of the knee (29.59%,  $n = 29$ ).

Table 7.6: Descriptive statistics depicting the most common locations of pain for all participants

Location of Pain	No. of Participants	% of Participants
Front of knee	52	53.06
Inside of knee	29	29.59
Outside of knee	17	17.34
Patella (kneecap)	26	26.53
Hip	5	5.10
Back/rear of knee	16	16.33
Lower back	19	19.39
Upper back	4	4.08
Shoulders/arms	15	15.31
Neck	7	7.14
Upper leg/thigh	8	8.16
Lower leg/calf/shin	19	19.39
Feet	9	9.18
Hands	3	3.06

### 7.7.2 Hearing Deficits

80 participants (81.7%) felt that they had no problems hearing and considered themselves to have no form of hearing loss. 18 (18.4%) participants felt that they had some loss of hearing but that this did not harm their ability to hear music in its entirety and they wished to continue with the study. Of these patients, three participants (3.1%) wore hearing devices in one out of two ears. All three participants with hearing devices were confident that they still wished to take part and that their hearing was in no way deficient or impaired when their device was operating correctly. They were asked to trial the headphones over their hearing devices and stated that they were happy with the fit and with the sound quality.

### 7.7.3 Mental Health Status

Responses from patients regarding anxiety and depression indicated that 15.5% ( $n = 15$ ) of participants felt that they suffered from anxiety and 28.9% ( $n = 28$ ) felt that they were depressed.<sup>4</sup> 15.5% ( $n = 15$ ) of participants were currently taking prescribed anxiety or depression medication.

### 7.7.4 Alternative Therapies and Relaxation

8.3% ( $n = 8$ ) of participants used some form of complementary therapy. Of these patients, the complementary therapies that were used were: aromatherapy (25%,  $n = 2$ ), massage (12.5%,  $n = 1$ ), reflexology (12.5%,  $n = 1$ ), osteopathy (12.5%,  $n = 1$ ), chiropractic (12.5%,  $n = 1$ ) and spiritualist healing (12.5%,  $n = 1$ ). One patient (12.5%) also mentioned their use of physiotherapy. 37.5% ( $n = 3$ ) of these patients used their complementary therapy on a weekly basis, 12.5% ( $n = 1$ ) used it daily, 12.5% ( $n = 1$ ) used it monthly and 37.5% ( $n = 3$ ) only used complementary therapy occasionally.

The majority of respondents (91.57%,  $n = 76$ ) felt that relaxation was important and that they relaxed most effectively by watching TV or films (37.3%,  $n = 31$ ) or by reading (34.9%,  $n = 29$ ). See Table 7.7 for full results. 57.8% ( $n = 48$ ) of participants were happiest relaxing in a chair, 24.1% ( $n = 20$ ) on the sofa and 18.1% ( $n = 15$ ) were at their most comfortable in bed. A small proportion of participants had tried using relaxation techniques (13.4%,  $n = 11$ ), and the techniques that were generally used were meditation (63.6%,  $n = 7$ ) or spoken relaxation instruction tapes/CDs (36.4%,

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<sup>4</sup>Care should be taken when interpreting this result as it is based upon self-reported feelings of depression and not upon documented clinical diagnoses of anxiety or depression disorders.

$n=4$ ). 82.6% ( $n = 71$ ) of participants stated that they enjoyed spending time in silence or in the quiet.

When participants were asked how they responded to pain, 51.2% ( $n = 42$ ) of participants stated that they just ignored their pain. 19.5% ( $n = 16$ ) tried to rest, 14.6% ( $n = 12$ ) relied on pain medication and 14.6% ( $n = 12$ ) felt that they got upset when they experienced pain and that they were unable to cope. In the context of daily pain, 57.3% ( $n = 47$ ) of patients preferred to be on their own and away from friends and family when they were in pain.

### 7.7.5 Sleeping Habits

70.5% ( $n = 62$ ) of patients felt that their sleep was problematic and was easily disturbed. The reasons for their disturbed sleep were given as pain (33.9%,  $n = 21$ ), noise (17.7%,  $n = 11$ ) or both pain and noise (38.7%,  $n = 24$ ). Six participants (8.7%) also felt that they struggled with a disturbed sleep pattern (circadian rhythm). Further chi-square analysis into sleep disturbance showed that 1 cell had an expected count of less than 5, so an exact significance test was selected for Pearson's chi-square. There was no relationship between Group Allocation and Sleep Disturbance ( $\chi^2 = 6.545$ ,  $df = 4$ ,  $exact p = NS$ ). Concentration was a concern for participants and 27.3% ( $n = 24$ ) felt that they were easily distracted. They felt that the distraction was

Table 7.7: Descriptive statistics showing preferred modes of relaxation for participants

Mode of Relaxation	n	%
Sleep	4	4.8
Reading	29	34.9
Gardening	5	6.0
TV/Films	31	37.3
Golf	1	1.2
Work	2	2.4
Bowls	1	1.2
Music	4	4.8
Crafts	6	7.2
<b>Total</b>	<b>83</b>	<b>100</b>

as a direct result of their pain (66.7%,  $n = 12$ ), or was due to noise (5.6%,  $n = 1$ ) or both pain and noise (22.2%,  $n = 4$ ).

### 7.7.6 Work Status

76 patients (77.55%) were retired at the time of their surgery and 22 patients (22.45%) were still working but had been allocated leave of absence for their surgery and subsequent recovery.

### 7.7.7 Pharmacological Usage

The majority of patients ( $n = 85$ , 87.6%) utilised pain medication on a daily basis. This pain medication primarily consisted of the use of GP-prescribed opiate-based analgesics ( $n = 56$ , 58.3%).

## 7.8 Music

In order to maintain blinding to Group Distribution, control group participants did not complete this section of the Pre-admissions Clinic questionnaire. The responses below therefore reflect only the responses from the experimental group participants and 20 control group participants (20.4%) have not provided answers to this section.

Table 7.8: Descriptive statistics showing pre-operative medication usage for all participants

Medication Type	No		Yes		Total	
	n	%	n	%	n	%
Pain Medication	12	12.4	85	87.6	97	100
Salicylates	73	75.3	24	24.7	97	100
Arylalkanoics	84	86.6	13	13.4	97	100
Profens	82	85.4	14	14.6	96	100
Tricyclic Antidepressants	84	87.5	12	12.5	96	100
SSRIs	95	99.0	1	1.0	96	100
Opiates	40	41.7	56	58.3	96	100



### 7.8.1 Track Selection

The selection of tracks by participants is detailed in Table 7.9. The most popular track for the ‘++’ group was the Smooth Jazz collection (Track 5,  $n = 5$ , 27.8%). For the ‘+-’ group it was the Adagietto from Symphony 5 by Mahler (Track 1,  $n = 15$ , 71.4%). The ‘-+’ group preferred Mike Oldfield’s Tubular Bells and Pat Metheny’s Sirabhorn and Unity Village equally (Tracks 2 and 4,  $n = 7$ , 38.9%). Finally, the ‘--’ group chose to listen to Tommy Smith’s Into Silence collection (Track 4,  $n = 14$ , 66.7%).

No participants who were allocated to the ‘++’ group selected the Scottish harp music. This suggests that Scottish music was not preferred over the other musical extracts for the participants in the ‘++’ group.

### 7.8.2 Sleep Intra-intervention

During the intervention time period, many participants reported falling asleep.<sup>5</sup> On Day 1 29.66% ( $n = 28$ ) participants fell asleep, on Day 2 36.57% ( $n = 34$ ) of patients slept, on Day 3 29.86% ( $n = 23$ ) fell asleep, on Day 4 31.37% ( $n = 16$ ) slept and on Day 5 30.77 ( $n = 8$ ) of participants fell asleep during their intervention. Descriptive statistics by Group are shown in Table 7.10.

A 3x5 repeated-measures ANOVA was computed on Sleep Intra-intervention using the within-subjects factor of Day of Testing (3 levels; Days 1–3) and the between-

<sup>5</sup>It should be noted that this effect was not as a result of sedative medication. No patients were given sedative medication for the deliberate induction of sleep. All medication provided was as detailed in the anaesthetic regimen.

Table 7.9: Track Selection According to Group Distribution

	++		+-		-+		--	
Track No.	n	%	n	%	n	%	n	%
1	2	11.1	15	71.4	1	5.6	1	5
2	3	16.6	2	9.5	7	38.9	5	25
3	5	27.8	1	4.8	0	0	0	0
4	1	5.6	3	14.3	7	38.9	14	70
5	0	0	0	0	3	16.7	N/A	N/A
6	7	38.9	N/A	N/A	N/A	N/A	N/A	N/A
<b>Total</b>	18	100	21	100	18	100	20	100

subjects factor of Group. There was no significant difference between Groups ( $F_{(4,69)} = .437, NS$ ) indicating that groups were comparable in the number of patients who fell asleep during the period of their intervention. No particular category of music was more sleep-inducing than any other category or the control intervention. There was no significant main effect of Day of Testing ( $F_{(1,69)} = .191, NS$ ) or any further interactions.

### 7.8.3 Musical Involvement and Education

67.9% ( $n = 53$ ) of all experimental group participants did not consider themselves to play a musical instrument, though 32.1% ( $n = 25$ ) had played a musical instrument in their lifetime. The most popular musical instrument to play was the piano (17.9%,  $n = 14$ ), followed by voice (5.1%,  $n = 4$ ). Three participants (3.8%) played folk instruments: two choosing the bagpipes and one playing the accordion. A further five participants had some instrumental experience; two participants played woodwind instruments (2.6%,  $n = 2$ ), two played percussion and drum kit (2.6%,  $n = 2$ ) and one played the guitar (1.3%,  $n = 1$ ). 32% ( $n = 8$ ) of participants who played a musical instrument had done so for approximately 5–10 years and 24% ( $n = 6$ ) had played for over 10 years. However, only three participants still played their musical instrument at all (12%,  $n = 3$ ). Of the 25 participants who played a musical instrument, 23 (92%) had undertaken a minimum of 6 months of Formal Instrumental Musical Tuition (FIMT) on their chosen instrument. The majority of formally tutored participants had taken instrumental lessons for between 5 and 10 years ( $n = 10, 43.5%$ ; see Table 7.11).

Univariate between-subjects ANOVAs were conducted to investigate the impact of musical experience through Group Allocation. There was no significant effect of length of time (years) spent playing a musical instrument ( $F_{(3,21)} = .548, NS$ ) or of amount of Formal Instrumental Musical Tuition (years) ( $F_{(3,19)} = .606, NS$ ). This indicates that the experimental groups were equally matched in their distribution of formally trained musicians or participants who had played musical instruments in the past.

### 7.8.4 Music Listening Habits

74.4% ( $n = 58$ ) of experimental group participants regularly engaged in music listening, in contrast to 25.6% ( $n = 20$ ) of participants who felt that they rarely, if ever,

Table 7.10: Descriptive statistics showing the number and the percentage of participants to fall asleep during their intervention period

Group	Day 1				Day 2				Day 3				Day 4				Day 5			
	No		Yes		No		Yes		No		Yes		No		Yes		No		Yes	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Control	16	16.84	3	3.16	11	11.83	7	7.53	9	11.69	7	9.09	6	11.76	5	9.80	4	15.38	3	11.54
++	15	15.79	3	3.16	12	12.90	5	5.38	11	14.29	2	2.60	10	19.61	1	1.96	7	26.93	0	0
+ -	13	13.68	7	7.36	14	15.05	7	7.53	14	18.18	4	5.19	8	15.69	2	3.92	4	15.38	2	7.69
- +	10	10.54	8	8.42	11	11.83	7	7.53	11	14.29	4	5.19	5	9.80	3	5.89	2	7.69	0	0
--	13	13.68	7	7.36	11	11.83	8	8.60	9	11.69	6	7.79	6	11.77	5	9.80	1	3.85	3	11.54
<b>Total</b>	67	70.45	28	29.66	59	63.43	34	36.57	54	70.14	23	29.86	35	68.63	16	31.37	18	69.23	8	30.77

Table 7.11: Descriptive statistics for experimental group participants with a formal musical background

	Years Playing		Years of FIMT	
	n	%	n	%
Less than 1 year	5	20	4	17.4
1-2 years	2	8	3	13
3-4 years	4	16	5	21.7
5-10 years	8	32	10	43.5
10+ years	6	24	1	4.3
<b>Total</b>	25	100	23	100

listened to music. The mean length of time spent each week listening to music was 19.62 hours ( $\sigma = 24.60$ , range 0–112). The radio was the most popular format of music listening, with 54.1% ( $n = 40$ ) participants choosing to tune in to a radio station. CDs were also very popular, with 45.9% ( $n = 34$ ) of participants using this format of music listening. The majority of music listening took place as a passive activity: playing music in the background whilst engaging in another activity (78.4%,  $n = 58$ ). It was still relatively common to sit down and spend time in active, focussed music listening, however, and 16.2% ( $n = 12$ ) of participants felt that this was their preferred way of listening to music. 5.4% ( $n = 4$ ) of participants considered themselves to use both types of listening equally often.

Of those participants who felt that they did listen to music regularly, 19.4% ( $n = 13$ ) stated that they listened to music ‘constantly’, both actively and passively. Aside from these constant music listeners, the most popular times to listen to music were when driving (31.3%,  $n = 21$ ) and in the evenings (10.4%,  $n = 7$ ). See Table 7.12 for the complete responses.

## 7.9 Primary Outcome Measures

### 7.9.1 Brief Pain Inventory: Mean Pain Interference

To look firstly at the primary outcome measure of Mean Pain Interference on the Brief Pain Inventory, three one-way ANOVAs were computed to investigate the impact of

Table 7.12: Preferred times of day to listen to music

	Preferred Time to Listen to Music	
	n	%
AM	5	7.5
PM	7	10.4
Evening	10	14.9
Driving	21	31.3
Housework	5	7.5
Bedtime	6	9.0
Constantly	13	19.4
<b>Total</b>	<b>67</b>	<b>100</b>

Table 7.13: Descriptive statistics showing musical genre preferences

	Liked Genres		Disliked Genres	
	n	%	n	%
Choral/Opera	8	10.3	6	7.7
Classical	18	23.1	1	1.3
Country and Western	14	17.9	2	2.6
Easy Listening	9	11.5	1	1.3
Folk	5	6.4	0	0
Jazz	4	5.1	14	17.9
Metal	0	0	3	3.8
New Age	1	1.3	0	0
Pop	7	9.0	27	34.6
Rap	0	0	8	10.3
Rock	3	3.8	12	15.4
60s/70s	5	6.4	0	0
All Genres	4	5.1	0	0
No Genres	0	0	4	5.1
<b>Total</b>	<b>78</b>	<b>100</b>	<b>78</b>	<b>100</b>

Group on all Days of Testing. There was no significant difference between groups on Day 1 ( $F_{(4,87)}=2.137$ , NS), Day 3 ( $F_{(4,77)}=.826$ , NS) or Day 5 ( $F_{(4,25)}=.085$ , NS).

Next, to look at the effect of Day of Testing on Mean Pain Interference, a 3x5 repeated-measures ANOVA was computed using the within-subjects factor of Day of Testing 3 levels; Pre-admissions Clinic, Day 1 and Day 3) and the between-subjects factor of Group (5 levels; according to the MMCR). Data from Day 5 was excluded from the analysis due to the large percentage of early discharges. There was a significant main effect of Day of Testing ( $F_{(2,144)} = 7.042$ ,  $p < .001$ ), with scores from the Post-operative Day 1 ( $\bar{x} = 6.23$ ,  $\sigma = 2.07$ ) significantly different from those of Day 3 ( $p < .001$ ;  $\bar{x} = 5.21$ ,  $\sigma = 2.21$ ). The magnitude of the changes in scores between Days of Testing is reported in Table 7.15. The change from Day 1 to Day 3 almost attained clinical importance (change = 0.95). There was also a two-way interaction between Day of Testing and Group ( $F_{(8,144)} = 2.250$ ,  $p < .03$ ), suggesting that the groups did not respond similarly from day-to-day in their Mean Pain Interference scores (see Figure 7.2 and Table 7.14). Where the -- and control groups showed a progressive reduction across the three Days of Testing, the ++, +- and -+ groups showed a rise from the PAC on Day 1 and decline on Day 3.

Table 7.14: Descriptive statistics showing Mean Pain Interference scores by Group on the Brief Pain Inventory

Group	PAC			Day 1			Day 3			Day 5		
	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$
++	20	6.18	2.33	18	6.01	2.97	17	5.15	2.00	7	5.74	1.76
+-	18	5.95	2.06	17	7.02	1.73	15	5.80	2.19	7	5.69	1.51
-+	21	5.38	1.97	20	6.85	1.68	19	6.10	1.64	8	5.67	2.54
--	18	5.55	2.19	18	6.05	1.83	15	4.36	2.70	2	4.67	4.72
Control	21	5.90	1.69	19	5.33	1.64	16	4.94	2.27	6	5.58	3.00
<b>Total</b>	98	5.79	2.03	92	6.25	2.07	82	5.30	1.19	30	5.60	2.25

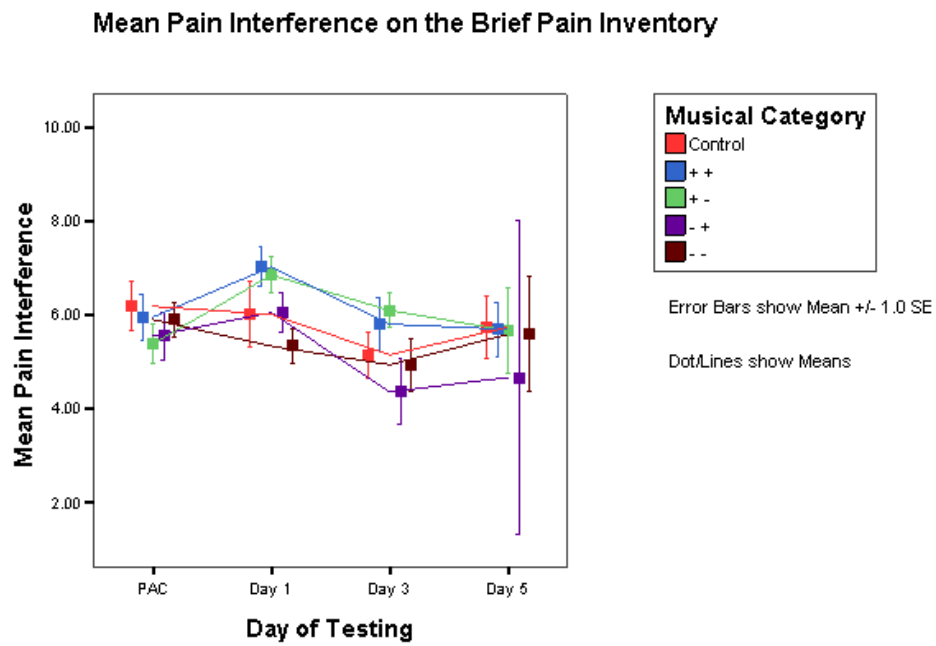


Figure 7.2: Line graph showing the changes in Mean Pain Interference scores across Day of Testing for the Brief Pain Inventory

Table 7.15: Change scores and % change in Mean Pain Interference on the Brief Pain Inventory at all assessment time points

Group	PAC to Day 1		PAC to Day 3		Day 1 to Day 3	
	Change Score	% Change	Change Score	% Change	Change Score	% Change
Control	0.17	2.75	1.03	16.81	0.86	14.31
++	-1.07	-17.98	0.15	2.52	1.22	17.38
+-	-1.47	-27.32	-0.72	-13.38	0.75	10.95
-+	-0.5	-9.01	1.19	21.44	1.69	27.93
--	0.57	9.66	0.96	16.27	0.39	7.32
<b>Total</b>	-0.46	-7.95	0.49	8.46	0.95	15.20

### 7.9.2 Short-form McGill Pain Questionnaire: Total Pain Score

To look next at the primary outcome measure of Total Pain Score, a series of one-way ANOVAs were computed to investigate the relationship between Group and Total Pain Score on each Day of Testing. There was no significant effect of Group on any Day of Testing, either at pre-test or post-test.

To investigate the impact of the intervention on Total Pain Scores, a 2x3x5 repeated-measures ANOVA was computed using the within-subjects factors of Time of Testing (2 levels; pre-test and post-test) and Day of Testing (3 levels, post-operative Days 1, 2 and 3) and the between-subjects factor of Group (5 levels; according to the MMCR). Data from days 4 and 5 was not included in the analysis due to the numbers of patients discharged.

There was a significant main effect of Day of Testing ( $F_{(2,136)}=13.133, p < .0005$ ), with Total Pain Scores on Day 1 scored most highly ( $\bar{x} = 15.63, \sigma = 11.03$ ), and then there was a gradual descent in scores through Day 2 ( $\bar{x} = 13.11, \sigma = 9.78$ ) and Day 3 ( $\bar{x} = 10.43, \sigma = 9.23$ ). A series of post-hoc tests showed that Days 1 and 2 were significantly different from Day 3 ( $p < .0005$  and  $p < .028$  respectively). Days 1 and 2 were not significantly different from each other. To represent this graphically, change scores were calculated by subtracting the post-test score from the pre-test score and mean change scores by Day of Testing are represented in Figure 7.3. There was also a significant main effect of Time of Testing ( $F_{(1,68)}=116.615, p < .0005$ ), with pre-test Total Pain Scores proving to be higher ( $\bar{x} = 15.89, \sigma = 8.90, p < .0005$ ) than post-test scores ( $\bar{x} = 10.66, \sigma = 8.35, p < .0005$ ). The magnitude of this change attained the boundary for clinical importance on all Days of Testing. There were no significant two-way interactions between Day of Testing and Group ( $F_{(8,136)}=1.432, NS$ ), between Time of Testing and Group ( $F_{(4,68)}=1.331, NS$ ) or between Day of Testing and Time of Testing ( $F_{(2,136)}=.559, NS$ ). Similarly, the three-way interaction between Day of Testing, Time of Testing and Group was not significant ( $F_{(8,136)}=.1552, NS$ ).

### 7.9.3 Profile of Mood States: Total Mood Disturbance

Three further one-way between-subjects ANOVAs were computed to investigate the impact of Group on the results from the Profile of Mood States Total Mood Disturbance Scores on post-operative days 1, 3 and 5. There was no significant difference between groups for any day of testing: Day 1 ( $F_{(4,87)}=.304, NS$ ), Day 3 ( $F_{(4,77)}=.506, NS$ ) and Day 5 ( $F_{(4,25)}=.054, NS$ ). See Table 7.16 for descriptive statistics. Mean Scores are



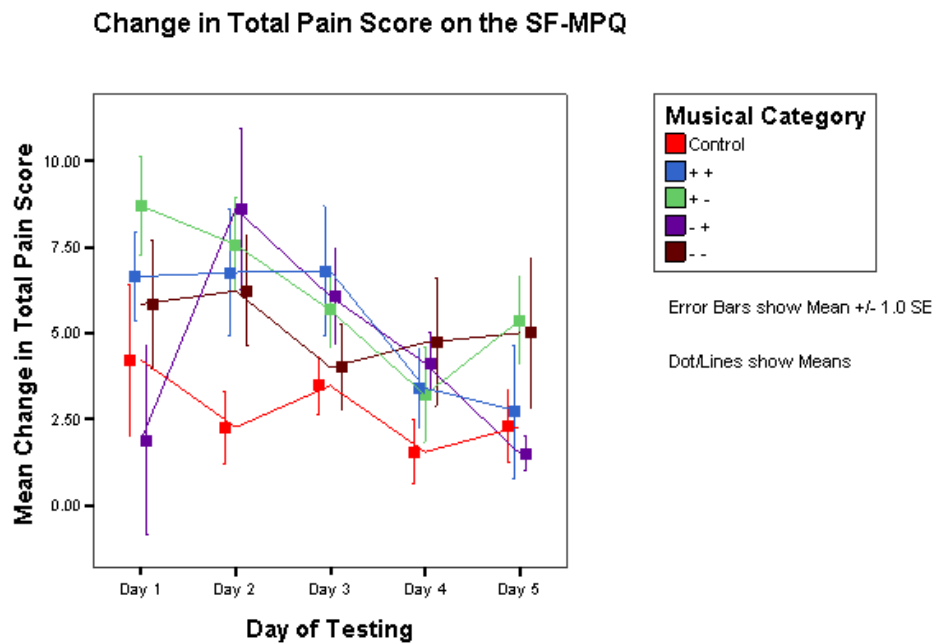


Figure 7.3: Line graph showing the changes in Total Pain Score across Day of Testing by Group for the Short-form McGill Pain Questionnaire

represented graphically in Figure 7.18.

A repeated-measures ANOVA was computed using the within-subjects factor of Day of Testing (3 levels; PAC, Day 1 and Day 3) and the between-subjects factor of Group (5 levels; according to the MMCR). There was a significant main effect of the Day of Testing ( $F_{(2,144)} = 15.2, p < .0005$ ). Indicating that there was a significant difference in the scores between each Day of Testing. Post-hoc tests revealed that Total Mood Disturbance was higher on Day 1 ( $\bar{x} = 27.08, \sigma = 32.05$ ) than at the Pre-admissions Clinic ( $\bar{x} = 5.90, \sigma = 27.43$ ) or on Day 3 ( $\bar{x} = 17.06, \sigma = 29.02$ ). The difference between the days was significant at all points: scores at the PAC were significantly different from Day 1 ( $p < .0005$ ), and Day 3 ( $p < .037$ ) and Day 1 was significantly different from Day 3 ( $p < .012$ ). There was no significant interaction between Day and Group ( $F_{(4,72)} = 1.091, NS$ ), indicating that the Total Mood Disturbance scores for the five different groups were not significantly different from each other on each Day of Testing. The level of change post-operatively between Day 1 and Day 3 attained the level required for clinical meaningfulness (see Table 7.17).

Table 7.16: Descriptive statistics for Total Mood Disturbance on the Profile of Mood States questionnaire

Group	PAC TMD			D1 TMD			D3 TMD			D5 TMD		
	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$
Control	20	10.55	33.90	18	29.44	34.48	17	15.65	28.78	7	23.00	30.34
++	18	8.44	30.32	17	33.76	41.54	15	23.27	42.25	7	19.71	46.23
+ -	21	-8.81	20.05	20	24.35	25.90	19	14.68	19.84	8	16.13	25.20
- +	18	12.39	25.97	18	24.33	26.97	15	10.40	18.09	2	19.50	33.23
--	21	8.43	22.50	19	24.31	32.71	16	21.81	33.24	6	24.00	40.81
<b>Total</b>	98	5.90	27.43	92	27.08	32.05	82	17.06	29.02	20	24.00	33.48

Table 7.17: Mean change and % change in Total Mood Disturbance from Day 1 to Day 3<sup>6</sup>

Group	PAC-Day 1		PAC-Day 3		Day 1-Day 3	
	Change Score	% Change	Change Score	% Change	Change Score	% Change
Control	-18.89	-179.05	-5.1	-48.34	13.79	46.84
++	-25.32	-300.00	-14.83	-175.71	10.49	31.07
+ -	-33.16	-376.39	-23.49	266.63	9.76	39.71
- +	-11.94	-96.37	1.99	16.06	13.93	57.25
--	-15.89	-224.08	-21.81	-258.72	2.51	10.32
<b>Total</b>	-21.18	-358.98	-11.16	-189.15	10.02	37.00

### 7.9.4 Physiological Assessment: Cortisol

62 participants (63.27%) agreed to provide cortisol samples in their post-operative recovery phase. One participant was unable to provide samples as they had recently undergone surgery to have their adrenal gland removed and therefore they did not produce any salivary cortisol. The remainder of participants choose not to give saliva samples due to: inability to master technique/dry mouth ( $n = 10$ , 10.20%), feelings of nausea ( $n = 8$ , 8.16%), dislike of 'spitting' ( $n = 4$ , 4.08%) or personal choice ( $n = 13$ , 13.27%).

Firstly, to evaluate the effect of Group on Cortisol Concentration, change scores were computed by subtracting the post-test scores from the pre-test scores for each Day of Testing. Five one-way ANOVAs were computed using the between-subjects factor of Group Allocation (5 levels; according to the MMCR). There was a significant main effect of Group on Day 1 ( $F_{(4,55)} = 3.139, p < .02$ ). A series of post-hoc tests revealed that the ++ group showed a significantly greater change from pre- to post-test scores in comparison with the -- group ( $p < .019$ ). There were no other main effects of Group on any of the post-operative days 2–5. Pre-admissions Clinic baseline data is shown in Table 7.18.

To investigate the effect of Group on Time and Day of Testing, a 2x3x5 repeated measures ANOVA was computed using the within-subjects factor of Time of Testing (2 levels; pre- and post-test) and Day of Testing (3 levels; post-operative days 1–3) and the between-subjects factor of Group Allocation (5 levels; according to the MMCR). There was a significant main effect of Day of Testing ( $F_{(2,74)} = .009, p < .01$ ; see Figure 7.6). Post-hoc tests revealed that scores on Day 1 ( $\bar{x} = 21.06, \sigma = 23.07$ ) significantly higher than those on Day 3 ( $\bar{x} = 9.55, \sigma = 9.27$ ;  $p < .01$ ; see Figure 7.5) but there was no significant interaction between Day of Testing and Group ( $F_{(8,74)} = .651, NS$ ). There was no significant main effect for Time of Testing ( $F_{(1,37)} = .945, NS$ ) or interaction between Time of Testing and Group ( $F_{(4,37)} = .461, NS$ ). There was no interaction between Day of Testing and Time of Testing ( $F_{(2,74)} = .055, NS$ ). There was, however, a significant three-way interaction between Day of Testing, Time of Testing and Group ( $F_{(8,74)} = 3.264, p < .005$ ). Post-hoc tests revealed that the ++ Group was significantly different from the -- Group on Day 1, but that the groups responded similarly on post-operative days 2 and 3. On Day 1, the ++ group dropped from  $\bar{x} = 28.38$  nmol/l to

$\bar{x} = 11.00$  nmol/l ( $p < .05$ ). The -- group, by contrast saw their pre-test concentrations rise from  $\bar{x} = 17.87$  nmol/l to  $\bar{x} = 25.61$  nmol/l (not significant; see Table 7.20 and Figure 7.7). See Tables 7.19 for descriptive statistics, and Figures 7.4 and 7.5 for graphical representations.

## 7.10 Secondary Outcome Measures

### 7.10.1 Subjective Measures: VRS/NRS

In order to test the difference between musical groups, a number of one-way ANOVAs were computed using the between-groups factor of Group (5 levels, according to the MMCR) and the dependent variables of VRS/NRS pain scores at Rest in the Morning

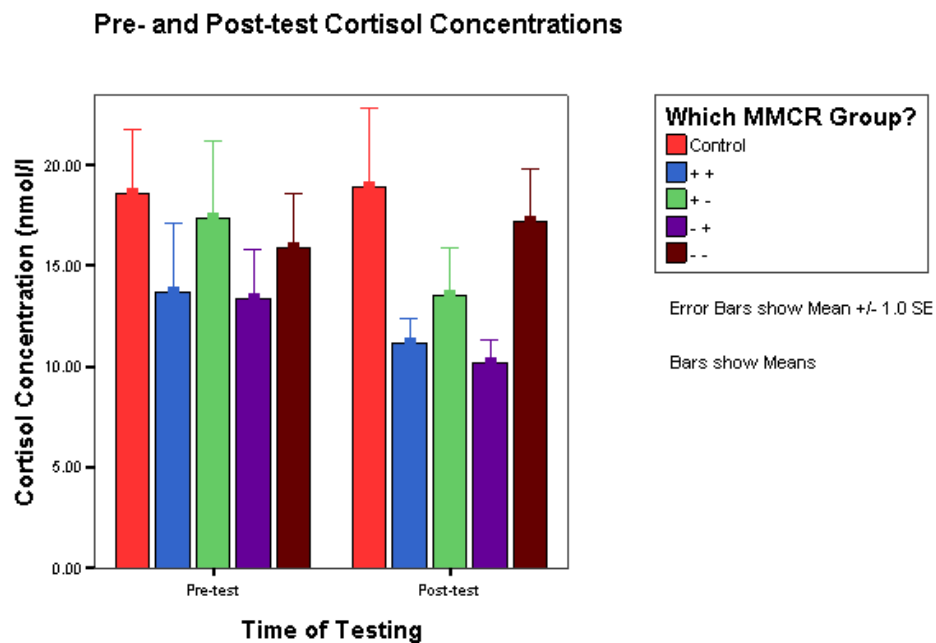


Figure 7.4: Overall mean Salivary Cortisol Concentration by Group according to Time of Testing

Table 7.18: Descriptive statistics showing means and standard deviations for overall Salivary Cortisol Concentrations according to Day of Testing

Group	Salivary Cortisol Concentration (nmol/l)																	
	PAC			Day 1			Day 2			Day 3			Day 4			Day 5		
	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$
Control	16	11.65	16.14	12	29.14	27.25	16	20.45	14.54	13	10.08	5.91	8	8.53	8.46	4	10.86	10.21
++	11	10.82	13.49	10	19.69	18.51	11	12.16	7.46	10	8.65	5.04	5	8.75	6.24	3	4.61	2.04
+ -	12	10.70	7.18	12	17.77	23.67	13	23.72	32.63	11	8.49	3.83	7	10.25	4.88	4	10.18	6.30
- +	14	14.64	17.91	14	20.82	20.59	13	9.52	3.35	11	9.89	8.98	5	6.81	3.54	3	6.41	1.88
--	14	10.89	7.79	16	21.74	13.63	13	12.93	8.28	9	16.23	11.92	6	6.41	3.92	4	4.75	3.16
<b>Total</b>	67	11.81	13.14	64	21.86	20.55	66	16.08	17.27	54	10.48	7.67	31	8.27	5.74	18	7.57	5.99

Table 7.19: Descriptive statistics showing mean and standard deviation change scores showing the difference between pre- and post-test Salivary Cortisol Concentrations (nmol/l change) according to Day of Testing

Group	Day 1			Day 2			Day 3			Day 4			Day 5		
	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$	n	$\bar{x}$	$\sigma$
Control	10	-5.66	20.45	16	3.73	18.91	13	-0.34	3.45	8	3.10	9.76	4	2.60	4.49
++	12	17.37	38.93	9	-8.38	11.55	10	-0.57	2.65	5	0.79	4.08	3	1.53	2.67
+ -	11	-1.83	8.28	12	5.03	13.33	11	1.45	5.49	7	2.31	9.31	4	-0.73	2.16
- +	16	4.64	15.38	13	2.03	5.94	11	1.00	6.37	5	-0.56	3.89	3	2.25	3.21
--	6	-7.74	23.69	12	0.63	3.05	9	2.94	26.91	6	2.43	7.36	4	2.49	4.49
<b>Total</b>	<b>60</b>	<b>0.28</b>	<b>20.49</b>	<b>62</b>	<b>1.27</b>	<b>12.82</b>	<b>54</b>	<b>0.80</b>	<b>11.32</b>	<b>31</b>	<b>1.83</b>	<b>7.38</b>	<b>18</b>	<b>1.60</b>	<b>3.43</b>

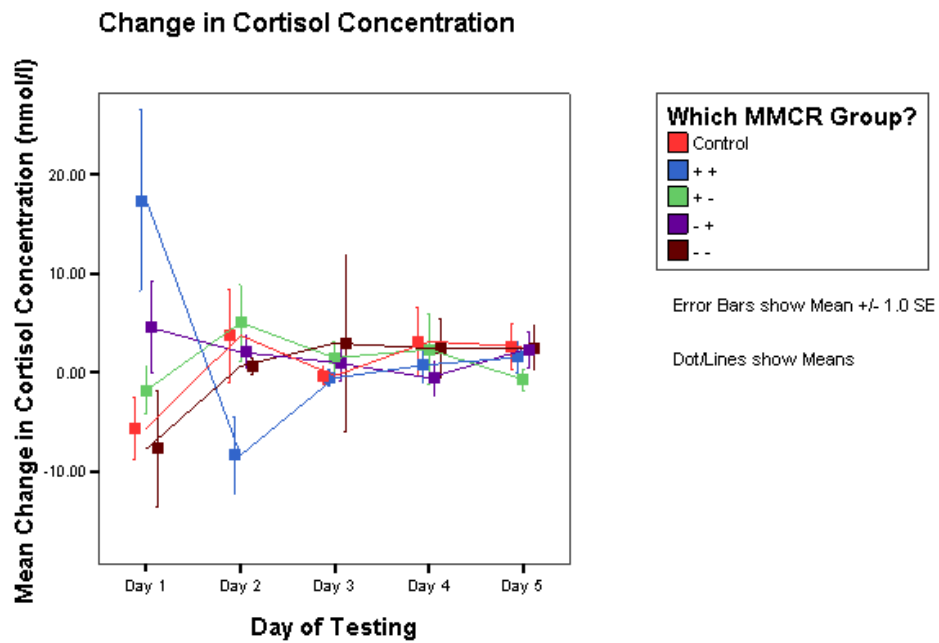


Figure 7.5: Mean changes in Salivary Cortisol Concentration by Group according to Day of Testing

Table 7.20: Pre- and post-test Cortisol Concentrations by Group on Day 1

Group	Day 1 Pre-test			Day 1 Post-test	
	n	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$
Control	11	27.47	24.55	31.74	31.28
++	10	28.38	32.65	11.00	6.14
+-	12	16.85	20.92	18.68	26.79
-+	13	23.13	23.89	14.37	9.35
--	16	17.87	10.88	25.61	23.11
<b>Total</b>	<b>62</b>	<b>22.17</b>	<b>22.32</b>	<b>20.93</b>	<b>22.64</b>

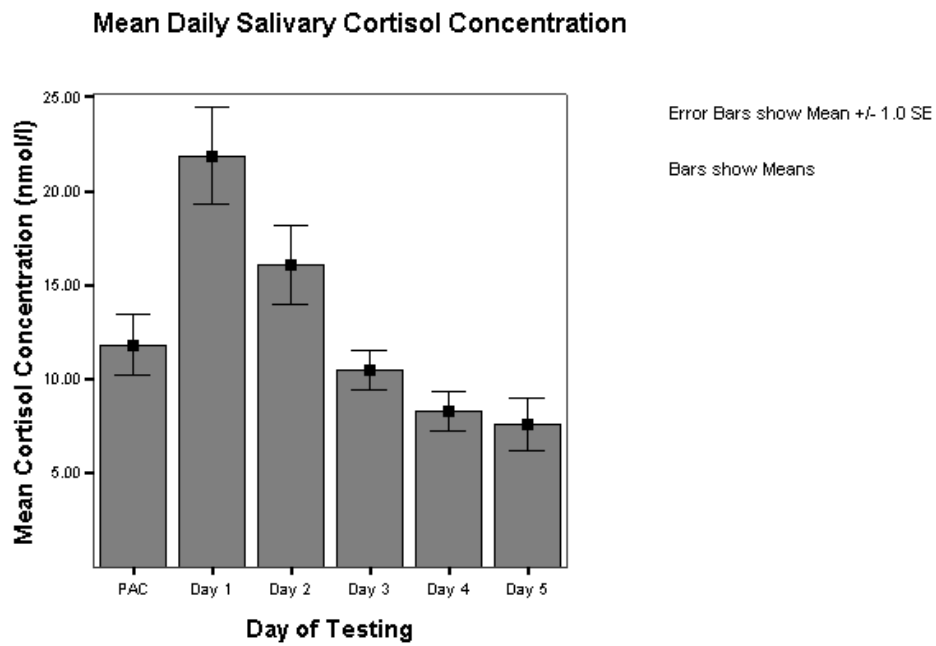


Figure 7.6: Overall mean Salivary Cortisol Concentration according to Day of Testing

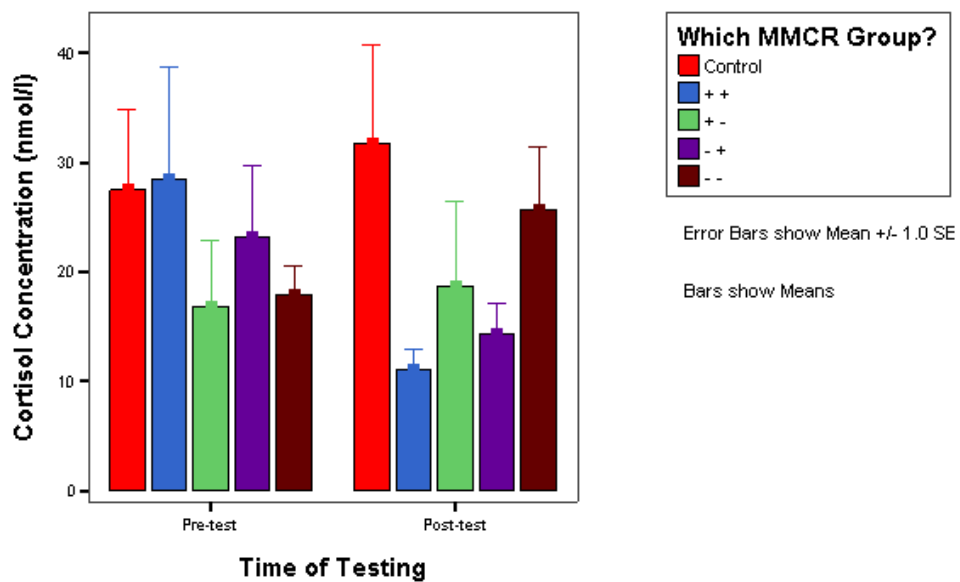


Figure 7.7: Bar chart showing mean Cortisol Concentration pre- and post-test on Day 1 of Testing according to Group Allocation



and Evening of each Day of Testing, and the pain scores at Movement similarly. There was no significant difference between groups in their pain scores at any stage whilst at rest. There was, however, a significant difference between groups in their pain scores at movement on the evening of Day 2 ( $F_{(4,81)} = 2.67, p < .04$ ) when the -- group was lower than the other groups, and in the morning of Day 4 ( $F_{(4,5)} = 3.12, p < .02$ ) when the ++ group rated their pain as higher than the other groups.

Looking at the difference between morning and evening pain scores, results are graphically represented in Figures 7.8, 7.9, 7.10, 7.11, 7.12 and 7.13. To analyse this in depth, a 2x2x3x5 repeated-measures ANOVA was computed using the within-subjects factors of Action (2 levels; rest or movement), Time of Testing (2 levels; morning and evening) and Day of Testing (3 levels; Day 1, Day 2, Day 3) and the between-subjects factor of Group (5 levels; according to the MMCR). The results from Days 4 and 5 were excluded due to the large percentages of patients discharged on those days. The main effect of Action was significant ( $F_{(4,42)} = 84.136, p < .0005$ ), with pain scores on Movement rated as higher and more painful ( $\bar{x} = 73.98, \sigma = 16.27$ ) than pain scores at Rest ( $\bar{x} = 61.74, \sigma = 19.61$ ). The main effect of Time of Testing was significant

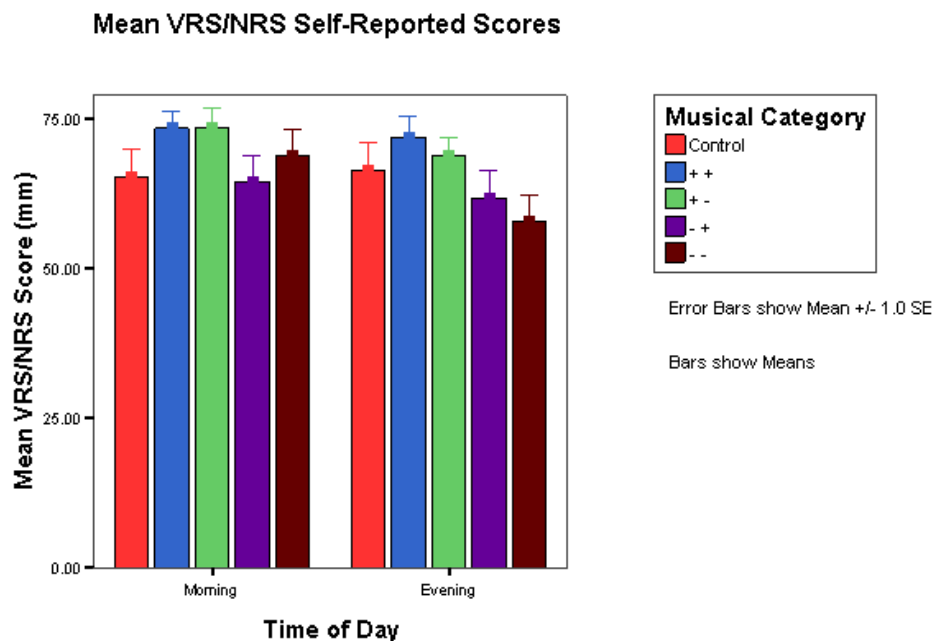


Figure 7.8: Bar chart showing VRS/NRS scores according to Group by Time of Testing

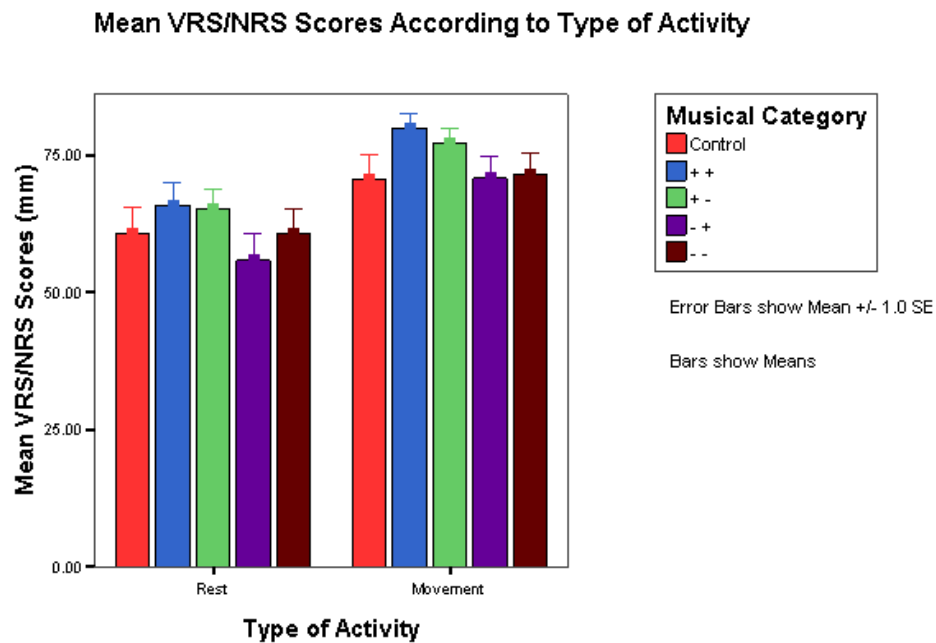


Figure 7.9: Bar chart showing VRS/NRS scores according to Group by Action Type

( $F_{(1,42)} = 38.793, p < .0005$ ) with patients experiencing more pain in the mornings ( $\bar{x} = 69.16, \sigma = 17.38$ ) than in the evenings ( $\bar{x} = 65.28, \sigma = 17.87$ ). The main effect of Day of Testing was significant ( $F_{(2,84)} = 3.068, p < .05$ ), with a trend towards lower pain scores on Day 3 ( $\bar{x} = 61.11, \sigma = 19.14$ ) than on Day 1 ( $\bar{x} = 69.85, \sigma = 20.07$ ) or Day 2 ( $\bar{x} = 69.73, \sigma = 18.83$ ). Scores on Days 1 and 2 were significantly different from those on Day 3 (Day 1:  $p < .004$ ; Day 2:  $p < .0005$ ), but not from each other. The two-way interaction between Time of Testing and Day of Testing was significant ( $F_{(2,84)} = 7.355, p < .001$ ). Post-hoc tests revealed that on Day 1 there was a 6.1% rise in pain score from the morning to the evening. On Day 2 and Day 3, however, there was a drop in pain score of 17.5% and 6.58% respectively from morning to evening. The three-way interaction between Action, Time of Testing and Day of Testing was significant ( $F_{(2,84)} = 3.74, p < .03$ ). Where the percentage rise from rest to movement in the morning essentially declines across Day of Testing (Day 1 = 17.37% rise; Day 2 = 9.91% rise; Day 3 = 10.62% rise), in the evening there is an increase in the rise (Day 1 = 10.2% rise; Day 2 = 11.05% rise, Day 3 = 20.78% rise).

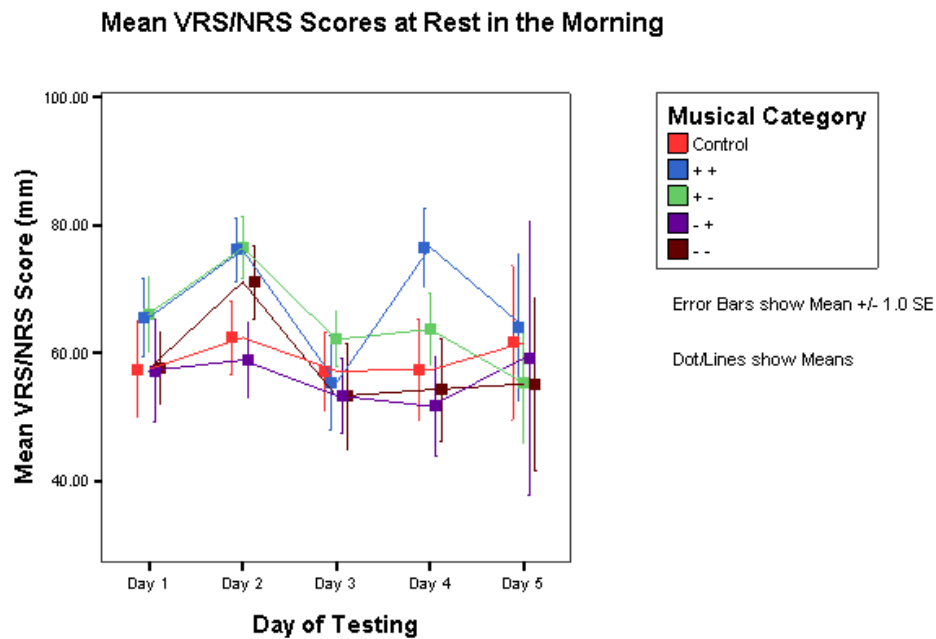


Figure 7.10: Line graph showing morning assessment VRS/NRS pain scores at Rest

### 7.10.2 Brief Pain Inventory

Investigating the data from the Brief Pain Inventory further, a number of one-way ANOVAs were computed. There was no main effect of Group for any of the subsidiary assessments of pain: Worst Pain Experienced, Mean Pain Severity, or Degree of Pharmacological Pain-relief.

Looking at these subsidiary dimensions of the Brief Pain Inventory across time, three 3x5 repeated-measures ANOVAs were computed using the within-subjects factor of Day of Testing (3 levels; PAC, Day 1 and Day 3) and the between-subjects factor of Group. There was no main effect of Group Allocation, but there was a significant main effect of Day of Testing on the Worst Pain Scores ( $F_{(2,144)} = 5.21, p < .007$ ), with the Worst Pain scored at the Pre-admissions Clinic as lower ( $\bar{x} = 6.74, \sigma = 1.92$ ) than the Worst Pain experienced on Days 1 ( $\bar{x} = 7.72, \sigma = 2.49$ ) or 3 ( $\bar{x} = 7.55, \sigma = 1.97$ ). Worst Pain Scores from the Pre-admissions Clinic were significantly different from those on Day 1 ( $p < .03$ ) or Day 3 ( $p < .02$ ). The 3x2 ANOVA on Mean Pain Severity showed no main effect of Day of Testing ( $F_{(2,144)} = 0.781, NS$ ) or Group ( $F_{(4,72)} = 0.930, NS$ ) or any further interactions. Finally, there was a main effect of Day of

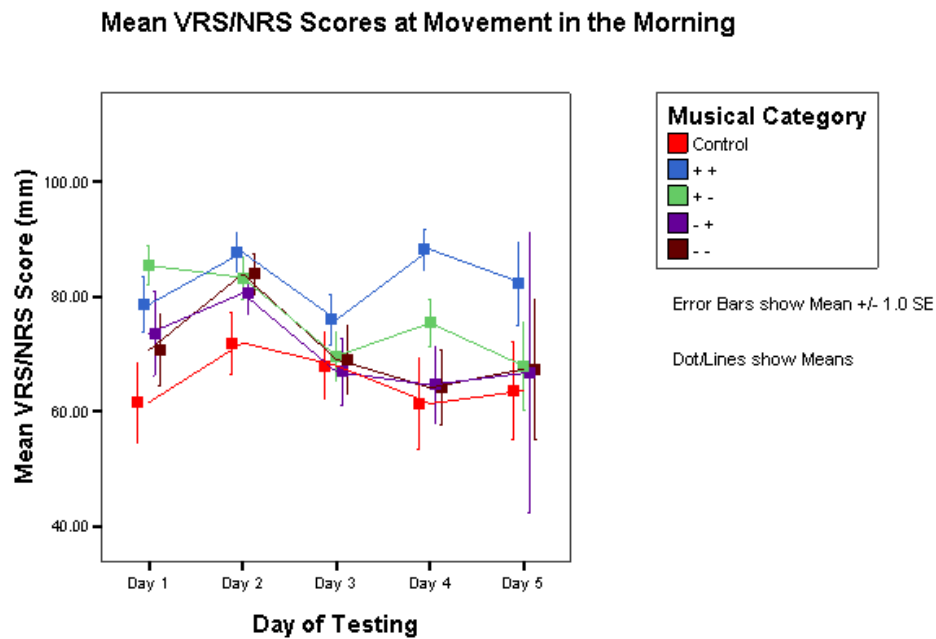


Figure 7.11: Line graph showing morning assessment VRS/NRS pain scores at Movement

Testing on perceived efficacy of Pharmacological Pain Relief as drug-induced pain relief was scored more poorly at the Pre-admissions Clinic ( $\bar{x} = 53.12\%$ ,  $\sigma = 28.80$ ) than Pharmacological Pain Relief in hospital on Day 1 ( $\bar{x} = 66.75\%$ ,  $\sigma = 25.52\%$ ) or Day 3 ( $\bar{x} = 67.27\%$ ,  $\sigma = 22.40\%$ ). Results from the PAC were significantly different from those on Day 1 ( $p < .005$ ) or Day 3 ( $p < .001$ ).

### 7.10.3 Short-form McGill Pain Questionnaire

To investigate the subset of scores summarily represented by the Total Pain Score of the Short-form McGill Pain Questionnaire, a series of repeated-measures ANOVAs were computed again using the within-subjects factors of Time of Testing (2 levels; pre- and post-test) and Day of Testing (3 levels; post-operative Days 1, 2 and 3) and the between-subjects factor of Group (5 levels; according to the MMCR). The SF-MPQ subsets used were Sensory and Affective dimensions of pain, Visual Ratings Scales at Rest and Movement and the Present Pain Index.

For the Sensory Dimension of Pain, there was a significant main effect of Time of

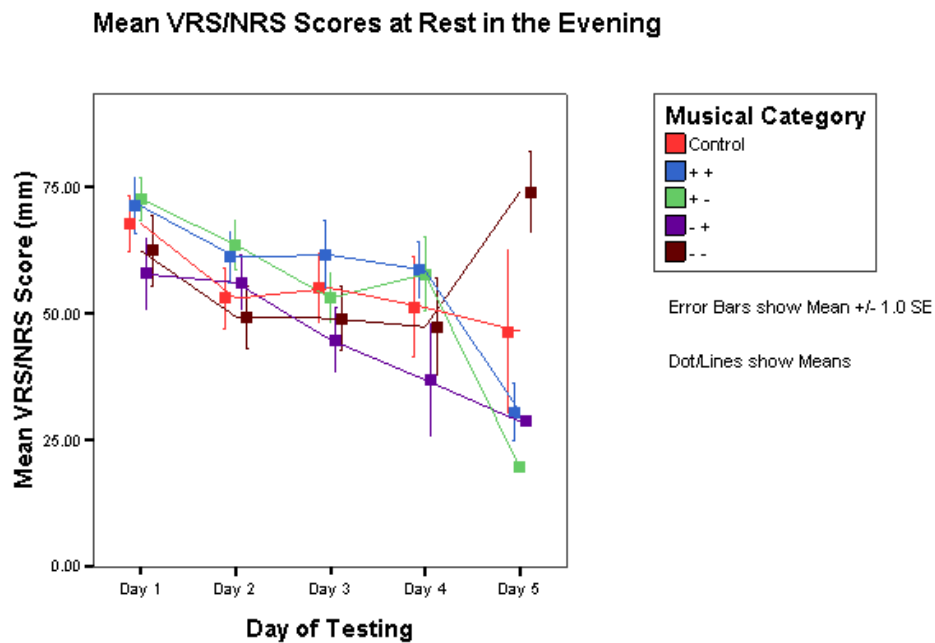


Figure 7.12: Line graph showing evening assessment VRS/NRS pain scores at Rest

Testing ( $F_{(1,68)} = 103.556, p < .0005$ ) with patients scoring higher pre-test ( $\bar{x} = 11.95, \sigma = 6.45$ ) than post-test ( $\bar{x} = 8.20, \sigma = 6.21$ ). The magnitude of this change was 31.35%. There was also a main effect of Day of Testing ( $F_{(2,136)} = 12.577, p < .0005$ ) as scores descended across the period of the study, with Day 1 at the highest ( $\bar{x} = 11.90, \sigma = 6.21$ ), followed by Day 2 ( $\bar{x} = 9.79, \sigma = 6.82$ ) and Day 3 at the lowest ( $\bar{x} = 8.20, \sigma = 6.82$ ). Day 1 was significantly different from Day 2 ( $p < .03$ ) and 3 ( $p < .0005$ ). There was no significant difference between Days 2 and 3. There was no significant main effect of Group and no further significant main effects or interactions. See Figure 7.15 and Figure 7.16 for graphs.

For the Affective Dimension of Pain, there was a significant main effect of Time of Testing ( $F_{(1,68)} = 77.832, p < .0005$ ), again with pre-test scores higher ( $\bar{x} = 3.83, \sigma = 2.65$ ) than post-test scores ( $\bar{x} = 2.37, \sigma = 2.37$ ). The magnitude of this difference was 38.12%. There was a main effect of Day of Testing ( $F_{(2,136)} = 8.209, p < .0005$ ), following the pattern of highest scores on Day 1 ( $\bar{x} = 3.68, \sigma = 2.76$ ) than Day 2 ( $\bar{x} = 3.28, \sigma = 2.91$ ) and then a larger reduction in scores by Day 3 ( $\bar{x} = 2.45, \sigma = 2.55$ ). Pairwise comparisons revealed that Days 1 and 2 were significantly different from Day 3 ( $p < .0005$  and  $p < .02$  respectively), but not from each other. There was no

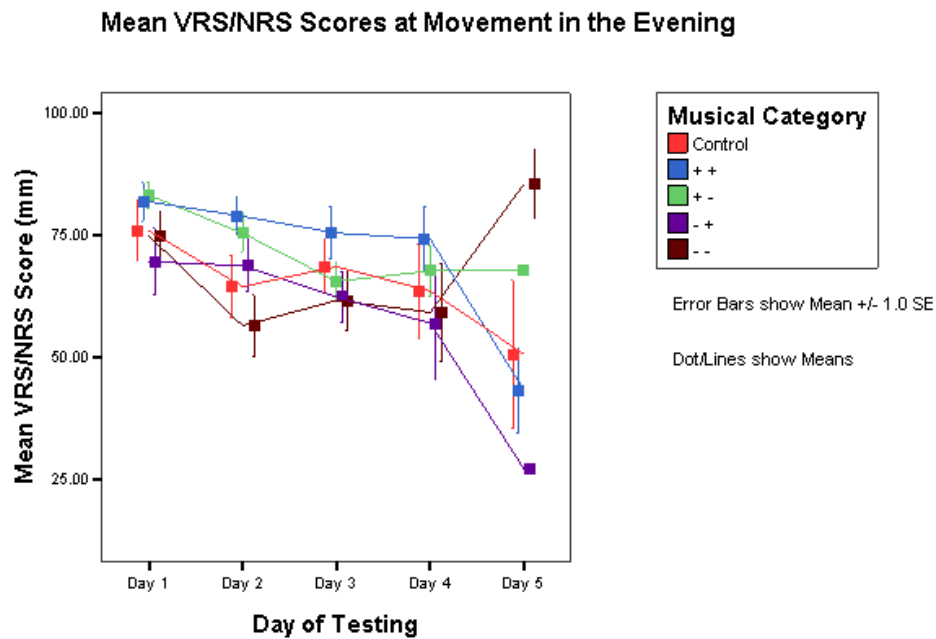


Figure 7.13: Line graph showing evening assessment VRS/NRS pain scores at Movement

significant main effect of Group and no further significant main effects or interactions.

For the SF-MPQ VAS ratings at Rest, there was a significant main effect of Time of Testing ( $F_{(1,68)} = 27.725, p < .0005$ ), with the pre-test scores higher ( $\bar{x} = 45.98, \sigma = 21.05$ ) than post-test scores ( $\bar{x} = 38.22, \sigma = 21.02$ ). The magnitude of this change was 16.88%. There was a main effect of Day of Testing ( $F_{(2,136)} = 8.373, p < .0005$ ), with a reduction in pain scores at Rest across the Days of Testing (Day 1:  $\bar{x} = 46.78, \sigma = 26.99$ ; Day 2:  $\bar{x} = 44.42, \sigma = 26.22$ ; Day 3:  $\bar{x} = 34.78, \sigma = 21.16$ ). Days 1 and 2 were significantly different from Day 3 ( $p < .001$  and  $p < .005$  respectively) but not from each other. There was no significant main effect of Group and no further significant main effects or interactions.

For the VAS ratings on Movement, there was a significant main effect of Time of Testing ( $F_{(1,65)} = 25.764, p < .0005$ ) with pre-test scores elevated ( $\bar{x} = 66.55, \sigma = 19.08$ ) in comparison with post-test scores ( $\bar{x} = 58.44, \sigma = 20.48$ ). The magnitude of this change was 12.19%. There was a significant main effect of Day of Testing ( $F_{(2,130)} = 12.243, p < .0005$ ), with scores reducing from Day 1 ( $\bar{x} = 71.01, \sigma = 21.57$ ) through to Day 2 ( $\bar{x} = 62.65, \sigma = 24.88$ ) and reaching a lower scores at Day 3 ( $\bar{x} =$

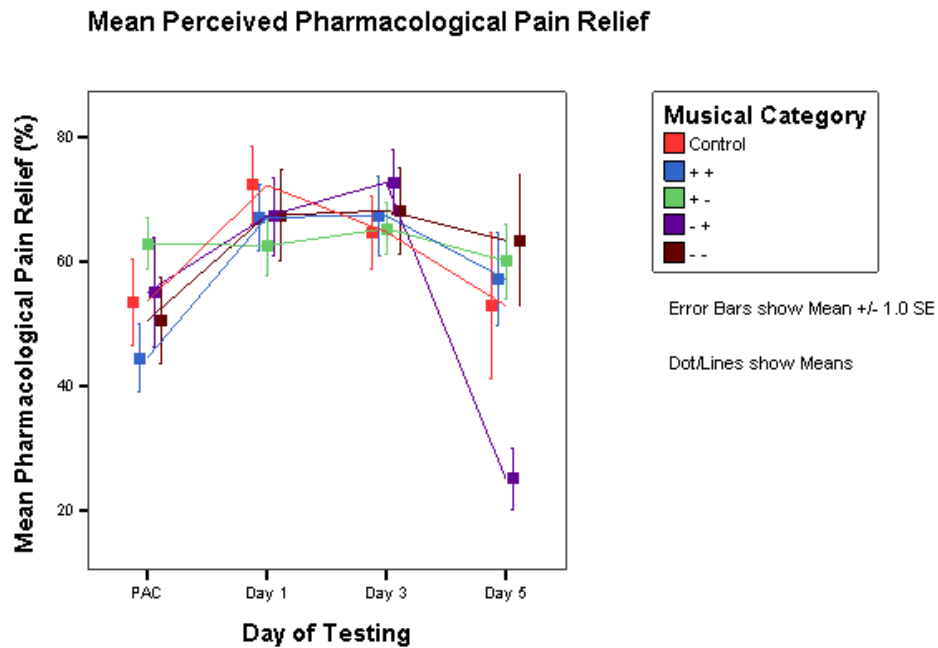


Figure 7.14: Line graph showing the percentage changes in perceived Pharmacological Pain Relief across Time of Testing for the Brief Pain Inventory.<sup>7</sup>

57.49,  $\sigma = 21.68$ ). Mean scores from Day 1 were significantly different from Days 2 ( $p < .03$ ) and 3 ( $p < .0005$ ). Scores from Days 2 and 3 were not significantly different from each other. There was no significant main effect of Group and no further significant main effects or interactions.

For the Present Pain Index,<sup>8</sup> there was a significant main effect of Time of Testing ( $F_{(1,68)} = 46.776, p < .0005$ ). Pre-test scores were higher ( $\bar{x} = 2.15, \sigma = 1.04, p < .0005$ ) than post-test scores ( $\bar{x} = 1.75, \sigma = 1.07, p < .0005$ ). The magnitude of this change was 18.6%. There was a main effect of Day of Testing ( $F_{(2,136)} = 11.508, p < .0005$ ), with subtle reduction in scores from Day 1 ( $\bar{x} = 2.17, \sigma = 1.25$ ) to Day 2 ( $\bar{x} = 2.13, \sigma = 1.26$ ) and Day 3 ( $\bar{x} = 1.54, \sigma = 1.07$ ). Pairwise comparisons revealed that Days 1 and 2 were significantly different from Day 3 (both  $p < .0005$ ) but not from each other. Though there was no significant main effect of Group ( $F_{(4,68)} = .509, NS$ ), there was a significant three-way interaction between Time of Testing, Day of Testing and Group Distribution ( $F_{(8,136)} = 2.462, p < .016$ ) (see 7.17). To explore this interaction, three one-way ANOVAs were computed on the change scores for Days

<sup>8</sup>Present Pain Index scores range from 0 (no pain) to 5 (excruciating).

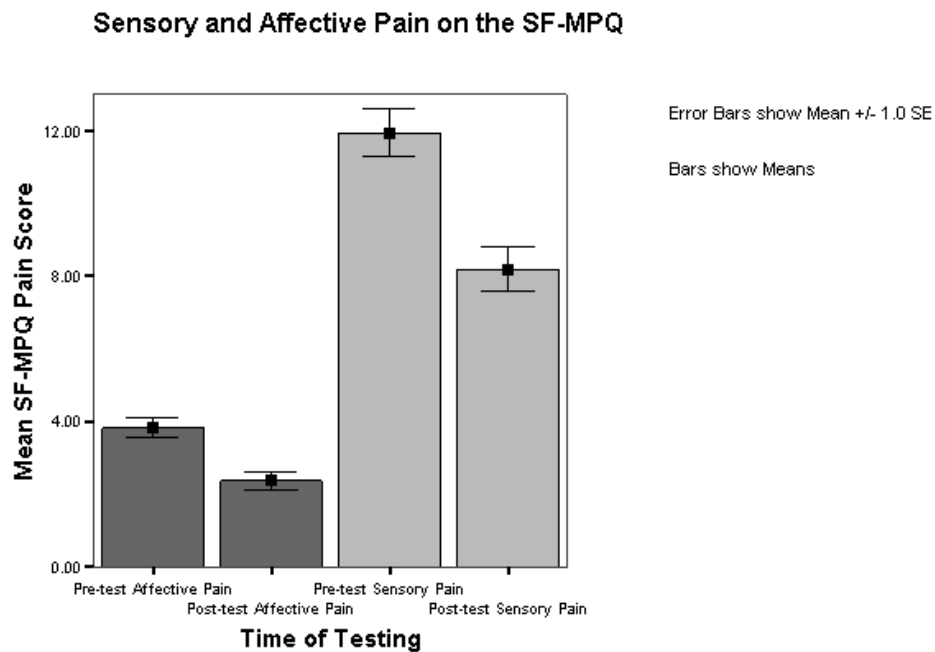


Figure 7.15: Bar chart showing mean pre- to post-test scores for Sensory and Affective pain on the Short-form McGill Pain Questionnaire for all participants

1–3 of Testing. Change scores were calculated by subtracting post-test from pre-test scores and are represented according to Group and Day of Testing in Figure 7.17. There was a significant difference between groups on Day 1 ( $F_{(4,90)} = 2.722, p < .05$ ) with (non-significant) trends towards a difference between the control group ( $\bar{x} = 0.17, \sigma = 1.20$ ) and the + – group ( $\bar{x} = 1.00, \sigma = 1.26$ ) and between the + + ( $\bar{x} = 0.06, \sigma = 0.9$ ) and + – groups (see before). To describe the patterning of the data, the + + group showed low levels of change on Day 1, and an increase in change by Day 3. The + – group showed a high change score on Day 1 and a decline in the degree of change by Day 3. The – + and – – groups showed a reduction in change from Day 1 to Day 2, but a slight increase again to Day 3. The control group showed low impact on Day 1 but an increase to Day 2 and then a decline again to Day 3. There were no further significant main effects or interactions.



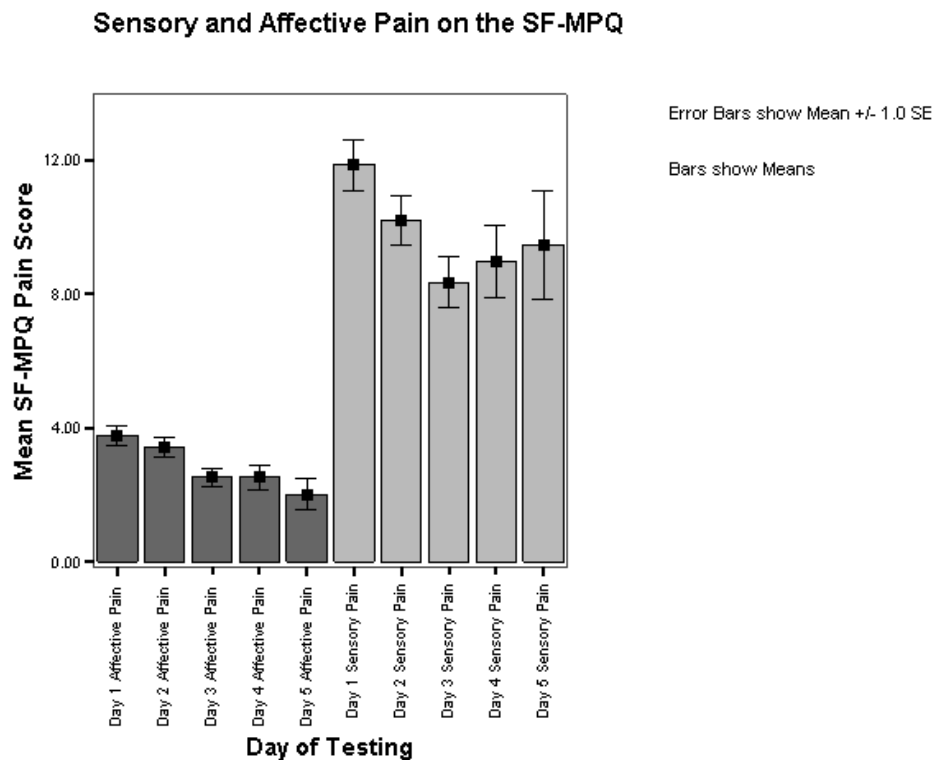


Figure 7.16: Bar chart showing mean scores for the Sensory and Affective pain on the Short-form McGill Pain Questionnaire by Group according to Day of Testing

#### 7.10.4 Profile of Mood States

To investigate the dimensions within the Total Mood Disturbance Score, repeated-measures ANOVAs were computed for each dimension of mood, using the within-subjects factor of Day of Testing (3 levels; PAC, Day 1 and Day 3) and the between-subjects factor of Group (5 levels; according to the MMCR). There was no significant interaction between Day and Group for any dimension of Mood, except the Confusion–Bewilderment dimension, indicating that no group is significantly different from another in their dimension-specific mood scores (excepting the Confusion–Bewilderment Dimension). All dimensions except Anger–Hostility ( $F_{(2,144)} = 2.401, NS$ ) showed a significant effect of Day of Testing. Tension–Anxiety ( $F_{(2,144)} = 8.293, p < .0005$ ) showed that scores from Day 1 were significantly different from those of Day 2 ( $p < .013$ ) but not Day 3 and scores from Day 2 were significantly different from Day 3 ( $p < .0005$ ). Depression–Dejection ( $F_{(2,144)} = 3.290, p < .04$ ) demonstrated that Day 1 was significantly different from Day 2 ( $p < .03$ ). Vigour–Activity ( $F_{(2,144)} = 26.061, p <$

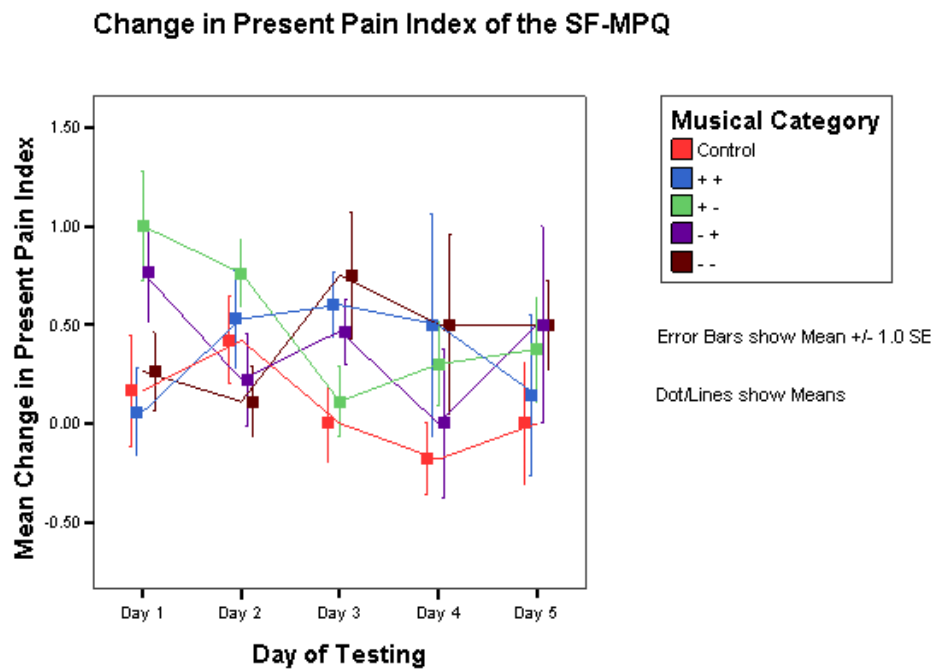


Figure 7.17: Line graph showing mean change scores according to Group Allocation on the Present Pain Index of the Short-form McGill Pain Questionnaire

.0005), showed that Day 1 was significantly different from Day 2 ( $p < .0005$ ) and Day 3 ( $p < .001$ ), with Day 2 was significantly different from Day 3 ( $p < .003$ ). Fatigue–Inertia ( $F_{(2,144)} = 30.555, p < .0005$ ) showed that Day 1 was significantly different from Day 2 ( $p < .0005$ ) and 3 ( $p < .0005$ ), as was Day 2 different from Day 3 ( $p < .001$ ). Finally, Confusion–Bewilderment ( $F_{(2,144)} = 12.189, p < .0005$ ) showed that Day 1 was significantly different from Days 2 ( $p < .0005$ ) and 3 ( $p < .03$ ). The Confusion–Bewilderment dimension also demonstrated a significant main effect of Group ( $F_{(4,72)} = 2.503, p < .05$ ), see Figure 7.19. Post-hoc tests revealed non-significant trends showing differences between the ++ ( $\bar{x} = 4.40, \sigma = 4.15$ ) and +- ( $\bar{x} = 1.89, \sigma = 3.09$ ) groups; the ++ and -+ ( $\bar{x} = 2.07, \sigma = 3.25$ ) groups; and the -+ and -- ( $\bar{x} = 3.45, \sigma = 4.05$ ) groups. Descriptive statistics are contained in Table 7.21.

Table 7.21: Descriptive statistics showing means and standard deviations for the sub-scales of the Profile of Mood States according to Day of Testing

Day of Testing	Tension–Anxiety		Depression–Dejection		Anger–Hostility		Vigour–Activity		Fatigue–Inertia		Confusion–Bewilderment	
	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$
PAC	4.57	7.07	5.17	6.59	5.45	6.23	15.68	7.39	6.43	6.77	1.52	4.17
Day 1	7.31	7.67	7.75	9.29	3.95	4.67	9.42	6.29	13.43	7.78	4.22	5.20
Day 3	4.11	5.71	6.55	8.14	5.10	6.67	11.99	11.99	10.09	7.27	3.03	4.60
<b>Total</b>	5.33	6.81	6.49	8.01	4.83	5.85	12.36	8.56	10.25	7.27	2.92	4.66

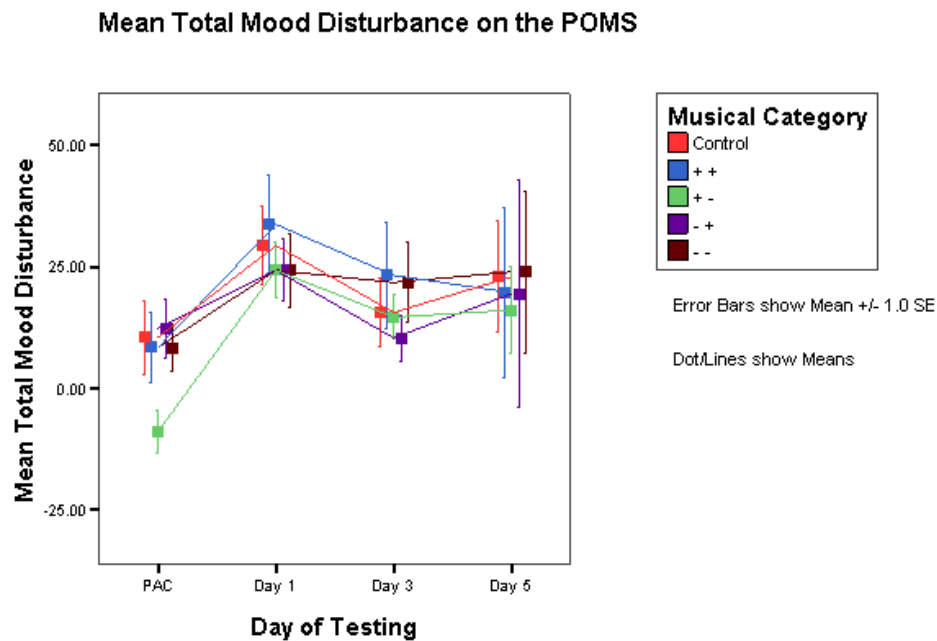


Figure 7.18: Line graph showing Total Mood Disturbance scores by Group across Day of Testing on the Profile of Mood States questionnaire

## 7.11 Qualitative Data

Data generated by the patients during their daily assessment visits and at their Feedback Interview were subjected to thematic content analysis. The use of thematic content analysis (see Robson, 1993) facilitated the identification of themes emergent in the data. From the data, four broad thematic categories emerge to represent the experience of the post-operative total knee replacement patient and their views on their interventions. These themes are mutually dependent and interacting categories, and together represent the totality of the uniquely individuated experience of clinical care and research participation for the patients. These qualitative results represent the themes of the personal experience throughout the study for all participants.

The four principal thematic categories are: (1) physiological, (2) psychological, (3) methodological and (4) musicological. Within the first three thematic categories, responses are separated by non-interventional responses and intervention-specific responses. Non-interventional responses were provided by participants before their music listening/quiet relaxation every day. Intervention-specific responses were com-

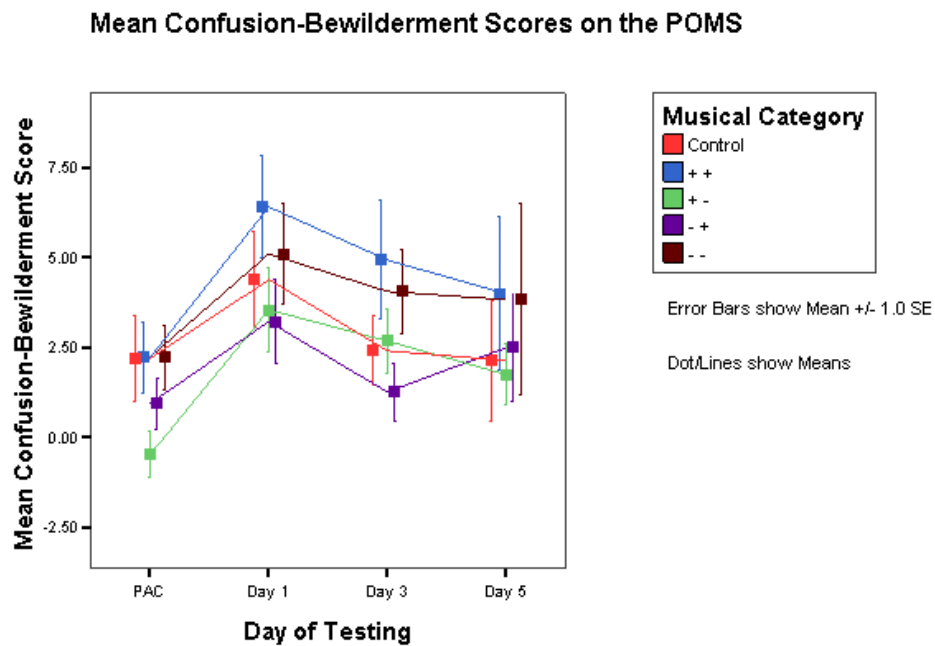


Figure 7.19: Line graph showing scores on the Confusion–Bewilderment dimension by Group across Day of Testing on the Profile of Mood States questionnaire

ments arising post-intervention and at the feedback interview undertaken before discharge.

## 7.11.1 Physiological Category

### 7.11.1.1 Non-interventional

In examining their status everyday, patients were daily concerned by physiological aspects of their health and condition and the changes and improvements to these over time. Of principal concern was the issue of significant pain; patients reported that; “The pain is murder today” or that “I’m in quite a lot of pain today”. Such comments about significant pain appeared across the course of the study, from Day 1 to Day 5. By Day 3, however, some participants felt that their pain was improving and for example, felt that “...my pain has improved quite a lot today in comparison to yesterday”. As the study progressed, more and more patients reported improvements in their pain levels, although many still continued to experience significant pain. The experience of pain and how high or low pain was perceived to be on a daily basis and in comparison with

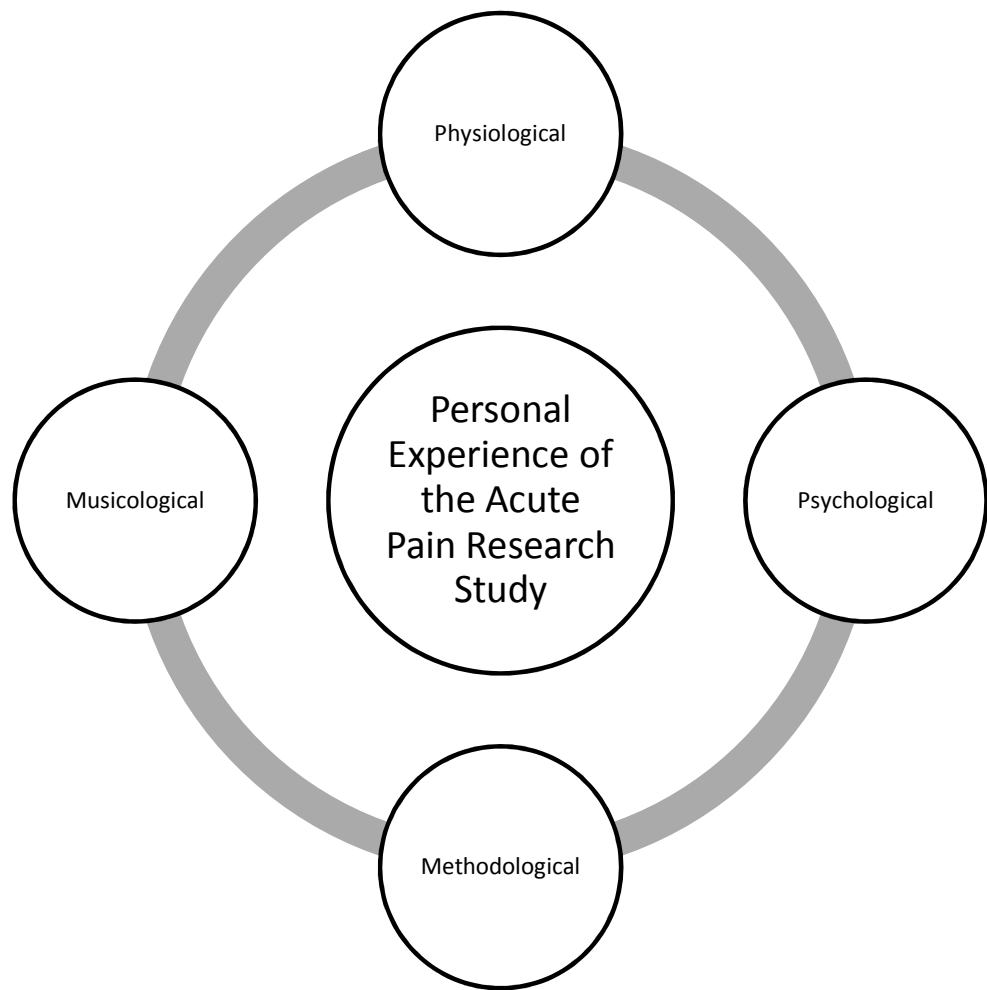


Figure 7.20: Qualitative data: the four thematic response categories

the day before was therefore a strong emergent theme. On Day 1, feelings of significant pain were also accompanied by pain behaviours such as groaning and sighing in some patients.

Nausea was a symptom which participants experienced and felt was a major influence upon their well-being and stay in hospital. Symptoms of nausea were noted by patients through until Day 4; “I was very sick last night” for example, and “I felt very sick and dizzy, not good first thing [this morning]”. Similarly, dizziness as a result of low blood pressure meant that patients felt “...very light-headed...I have very low blood pressure at the moment, but they are checking it regularly”. Knee-specific concerns were also of considerable importance to patients and they reported symptoms of shooting pain, stiffness and swelling; for example, “I had shooting pains last night and have found it hard to move in bed”; “My knee was very stiff last night and this morning”; “There’s lots of red swelling in my knee though”. Stiffness and swelling in particular were of greater concern to patients in the latter days of the study, and were often related to immobility throughout the night; “I did not sleep well due to pain and stiffness. It feels better when I’m moving”.

In addition to the physiological category and pain responses, a dominant theme included comments pertaining to sleep. Sleep deprivation was of primary concern to participants. Participants reported feelings of exhaustion on all days of assessment, for example, “I’m coping, but I’m just very tired” and “I’m shattered today”. This was related to feelings of an inability to sleep, such as “I had a bad night last night as I couldn’t get to sleep”, “I just couldn’t sleep and I cried a lot” and “I haven’t slept well throughout my stay in hospital”. Reasons given for this inability to sleep were personal as a result of pain, medical monitoring or noise. Regarding pain levels, patients commented that; “I couldn’t sleep last night as the pain was so severe”, “I slept badly as I had gnawing pains overnight”, and “I haven’t really slept that well because of the pain—maybe two or three hours”. As a consequence of medical monitoring patients felt that they; “[I] slept badly last night as I was just being disturbed a lot to take my heart rate and blood pressure”, “I had no sleep at all last night as the nurses were concerned about my insulin and blood sugar levels”. Due to noise on the ward it was noted that; “Last night I had hardly any sleep as it was so loud on the ward”, and “I had a bad night with noise. It was almost impossible to sleep as there was a man shouting from about 1–5am”. Such noise on the ward was regularly noted as a concern and it was not possible for the patient to reduce this as it was principally due to other people in the hospital, both patients and medical staff; “I would have slept last

night, but the nurses were back and forwards so one minute I was awake, the next I was asleep”. The frequency of comments about sleep indicates that participants considered this a very important theme and considered their lack of sleep to be inhibiting their recovery, for example, “...I’ve had very little sleep because of the pain. I’m feeling the impact of it, because sleep is a healer”.

### 7.11.1.2 Intervention-Specific

Intervention-specific results focussed principally on pain. Overall, responses showed the importance of induced pain relief. Responses were broadly two-directional: some participants were confident that their intervention had made a significant difference, “It’s taken away the pain when I was listening to the music” and “It reduced my pain quite considerably—on the first day it was quite dramatic”, while other participants felt that the intervention was not beneficial for their pain levels, stating “My pain levels weren’t changed” or “My pain levels did not change at all”. Looking deeper at the perceived benefits of the intervention on pain, participants seemed to differentiate between ‘actual’ pain reduction and ‘perceived’ pain reduction.

‘Actual’ pain relief was defined by patients as durable pain relief achieved through pharmacological analgesia. One patient commented that “I don’t know whether it’s helped or not. The pain is bad, but it comes and goes. One minute it’s good, and you think it’s getting better, and then the next you have a sharp pain. When you’re in pain, you’re in pain. I only know that painkillers work.” Some patients felt that the intervention did not provide any ‘actual’ pain relief: “I wouldn’t say that it affected my pain at all, though I think it probably could help”. The contrasting viewpoint was that of ‘perceived’ pain relief. ‘Perceived’ pain relief refers to the themes in which patients felt that their pain had been reduced or eliminated, but that this was not an absolute, biological reduction of their pain, but a diversion of attention away from their pain. Responses regarding ‘perceived’ pain relief suggested that, “It actually seemed to numb it. I just lay there and thought ‘this is wonderful’. You shut off from the rest of the ward, you listen to your music and you don’t feel the rest of your pain”, and “Your pain was gone, I didn’t think about the pain, I just enjoyed it [the music]”. Some patients consequently struggled to differentiate between ‘actual’ and ‘perceived’ pain relief and were not sure how the intervention had helped: “Once, it felt very pleasant, but otherwise my pain was not really affected...because you come at the end of the 1pm cocktail [of pain medication]”.

Patients had a variety of thoughts about the durability of the ‘perceived’ pain relief,



with some feeling that; “In the short-term I didn’t have any pain. I feel a lot better after listening to the music for some strange reason, until the nurses come round and then you’re back to square one again”. It was thought that the durability of the improvement could be residual: “There is an aftermath, it [pain relief] carries on, carries forward. If I was quietly sitting at home, I never tire of listening and the effect would have carried on for some time.” Others considered that the pain control was effective during the intervention and had a short residual effect, for example; “The pain relief lasted during the music and then for 5–10mins afterwards until you moved again”. Durability was also considered to be only and exactly for the duration of the intervention, for example, “I didn’t feel much pain during my relaxation, but now the relaxation has stopped, the pain has started to come back, very sudden and severe”.

The physiological category also contained themes to do with relaxation by reduction in muscular tension. Patients felt that “I just feel more relaxed and not so tense” and “In a way, when you’re relaxed, you’re sort of forgetting your pain”: patients clearly attributed relaxation to perceived pain reduction. In this way, the intervention featured both as a physical muscle relaxant, for example “It makes you so relaxed and your whole body feels soft, it’s brilliant. The pain’s eased off slightly [after the intervention]” and a psychological relaxant (see Section 7.11.2). Where the intervention had the potential to act as a relaxant, it also had the potential to activate muscle movement.

In the post-operative surgical population, for whom movement was potentially significantly painful, some patients found that their intervention, and in particular the ++ intervention made them want to move. Patients commented that, “I was tapping along—I like this one” and that “My foot on my bad leg was tapping throughout that”. The intervention therefore had both the potential to reduce and induce muscular activation, dependent on the mood, desires and engagement of the patient.

The final themes in the physiological category were those which also held significant concern for patients even before their intervention: sleep. These intervention-specific responses were concerned with the ability of the intervention to induce a sleep response. Patients commented that, “Two or three times I nearly fell asleep because of the music, which is unusual for me”, that “I just went away” and that “I fell asleep during the listening. I only heard about 10 seconds”. This soporific effect was also directly related to pain relief, for example, “It helped me to sleep intermittently and it dropped the pain back...”. Some patients felt that this connection between the intervention, sleep and pain relief was quite significant and commented that: “There’s a

link between the body and music—it's sleepy time! It's like a wave, the same today as yesterday. It's just something you look forward to actually. It's just a cosy-warmness in my knee now. The pain had left the leg and I fell asleep about three times." Sleep and the sleep response to the intervention, then, was a large part of the physiologically-themed responses.

## **7.11.2 Psychological Category**

### **7.11.2.1 Non-interventional**

Results from the qualitative data that represented emergent psychological themes were principally concerned with mood state. This was a two-directional theme as some participants reported feelings of positivity and satisfaction. On Day 1 this positivity was indicative of relief that the surgical procedure was over and that improvement in health would now follow; this was exemplified by comments such as "I feel happy; glad that the operation is over and that my knee will now be on the mend" or "I feel on top of the world". In later days of the study, positive mood was often related to progress in physiotherapy sessions, reduced pain, improved ability to cope or satisfaction at approaching discharge; "Physiotherapy went ok today and my pain is fine...I'm feeling great in myself", "I feel positive, and am coping well, despite the fact that the pain really hit me last night", "I'm much better today; it really doesn't compare to yesterday", "I'm feeling much more positive than yesterday. I'm ready to aim for home".

The contrasting viewpoint in the psychological category was that of negativity. The negativity theme reflected those participants who considered themselves to be in a bad mood, or felt that their spirits and emotional resources were low; "I had an awful night. I feel decidedly less chirpy today. The morphine wore off last night and by 10.30pm I was very sore". Responses reflecting mood state were often directly related to pain levels; negative responses were related to high pain levels, for example; "Last night was a bad night in a psychological way. I felt very down. The pain was quite severe until 6am". Similarly, perceptions of a positive mood state were allied to low pain levels, such as "I feel very happy today and have hardly any pain at all". Results from the psychological category as a whole clearly display the interrelation between psychological well-being and mood state and physiological symptoms, particularly as a result of significant pain.

Patients also reported the psychological theme of 'worry'. This theme encompasses worry about physiotherapy exacerbating problems with the knee post-operatively, for

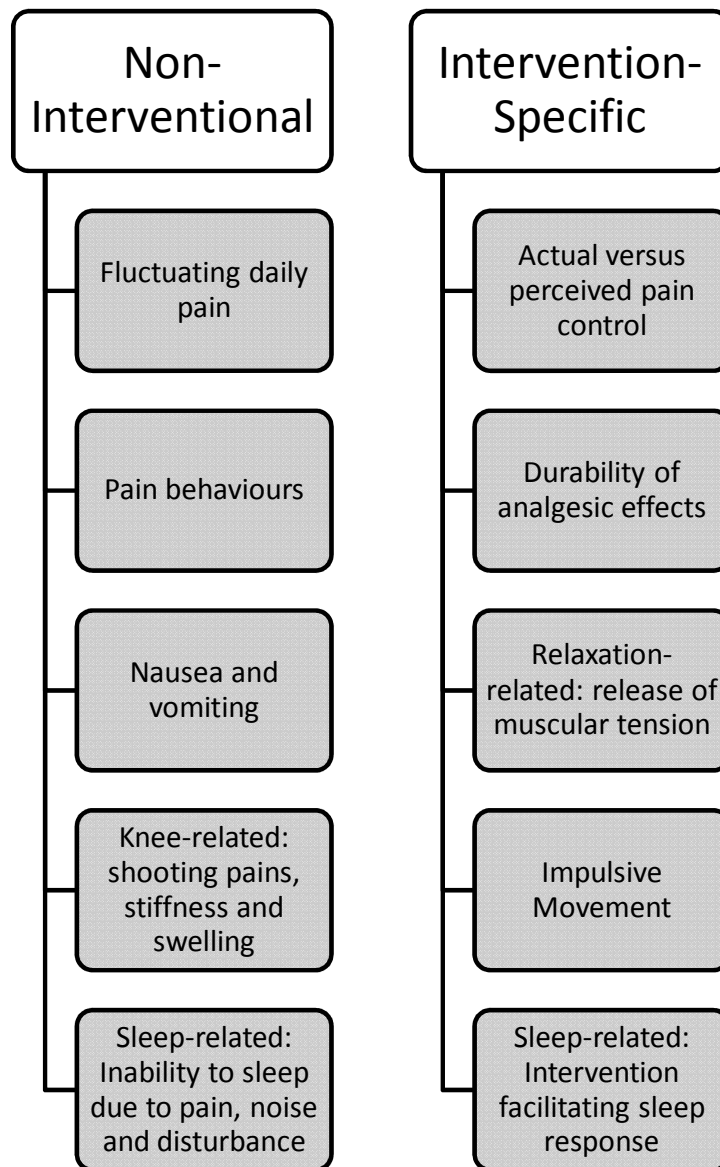


Figure 7.21: Contributing themes towards the emergent Physiological Category

example “If the knee will not move, it will not move. You can’t push it too hard. You have to be careful you don’t cause more damage”. Worry also pertained to pain—participants with low pain levels were concerned that their pain would soon increase dramatically, “I feel concerned that the pain will kick in shortly”.

The final psychological theme was the issue of ability to concentrate. Patients reported feeling that the pain and exhaustion that they experienced was affecting their concentration and their ability to settle into a task such as reading or watching television. This is exemplified by statements such as: “I just can’t concentrate today. I’ve tried TV and magazines and both are too much”. This inability to concentrate often led to feelings of frustration for participants, and by Day 5 frustration at lack of global improvement was a focus for the patients who remained in hospital, for example; “I’m looking forward to recovery, but I should be a bit faster than this. I’m frustrated that my knee is restricting me”.

### 7.11.2.2 Intervention-Specific

The first intervention-specific psychological theme, that of relaxation, is across categories and is both physiological and psychological in its content. Psychologically, patients found that the intervention induced a relaxation effect: “It made me more relaxed...” and “The music was relaxing in itself”. This relaxation effect took the form of specific feelings of relaxation, such as calmness, tranquility, shown in responses such as “The music was soothing. It was useful for me” and “The relaxation was really good. It was really tranquil”. In some cases, the relaxation effect was deliberately enabled by the patient, as patients stated that, “It’s listening for a different reason. As you’re doing it *to* relax, it’s totally different to at home”. Essentially, a theme of learned-association emerged; as participants perceived benefits in the early sessions, they facilitated relaxation in later sessions, thus learning to associate the intervention with the relaxation response. One patient commented regarding that: “There’s a link between the body and music—it’s sleepy time! It’s like a wave, the same today as yesterday. It’s just something you look forward to actually”. This indicates some active involvement in their intervention on the part of the patient.

The degree of absorption in the intervention session was considered important, “When you link up with the music, it pervades the body and it really is lovely, like how you would think about a nice dream. I had two interruptions though today, and my train of thought was aggravated about three times and I lost it. I never relaxed, right from the word go. You and the music need to be together”. Without some involvement in

the intervention and without being given ample opportunity to specifically relax, perhaps due to interruption, patients felt that the psychological benefits of the intervention could be lost.

This sentiment that the relaxation could be improved or, conversely, lost, was embodied in further themes of relaxation, those stating that the potential for relaxation was not uniform in its effect. Some patients reported that their ability to relax changed from day-to-day, “I enjoyed the music today. It was more relaxing than yesterday; I really got into it.” This was both positive and negative, with some participants finding the intervention progressively more relaxing, for example, “I was getting to the stage where the more I was doing it, the more I was relaxing when I was listening”, whereas others found the relaxation effect diminished; ““The first day was very relaxing, Day 2 was not so relaxing, and today [Day 3] was not relaxing at all”. The prime contributor to changes in absorption were reflected in themes regarding distraction. Some patients found that they were easily able to focus on their intervention and were not distracted: “I was quite focussed on the music”, “I didn’t get distracted” and “I wasn’t aware of anything that was going on around me. You can go into your own space as I call it”. Other participants stated that they were distracted by external events: “I have been quite distracted by football or by the other people in the ward” and “I was distracted by the general noise”. This was thought to have a direct impact upon their degree of absorption: “I got distracted on Day 3. I just opened my eyes and that was it, I was not into it”. Some patients specifically related that they struggled with concentration and that this was a concern for them; “The music would have been ok if I’d been feeling better. I just wanted it to stop as I couldn’t concentrate on it” and “I would find it hard to concentrate were I in more pain and trying to listen to the music”. It was also deemed important to concentrate when listening; “It helps to concentrate on music and to take your mind off [your pain]”.

Distraction and concentration was related by patients to their thoughts. Patients either considered that their thoughts had been blank or that they had been thinking about specific things/events. Some participants were confident that they had not been thinking during their intervention: “I wasn’t thinking at all. I totally switched off” and “I wasn’t thinking about anything. I just listened”. Other patients were thinking about going home, for example, “I was just thinking about whether I’m going home” or about relatives; “I thought about my family, what’s going to happen when I go home and in the future”. Thought was a dominant theme personally, but was also directed by the intervention. The intervention enabled some participants to use imagery in their

thought-lives: “I was thinking about the music and trying to describe what would go best with the music. For the first part it would be dolphins and for the second part it would be lovers running through fields with not a care in the world. I felt like it was me doing that”. Patients were actively guiding their thoughts to intervention-generated images, such as “I imagined being in Latin America and drinking cocktails” and also to personally-generated and personally-resonant images, for example, “I was thinking of the walk to Silvernowes...I walked further [along the beach] today”. Thoughts, therefore were clearly important psychological themes.

Anxiety reduction was a further key theme in the psychological category. Patients associated the relaxation and intervention with an anxiolytic effect, for example, “Anxiety was the main change. You just get total relaxation and don’t feel so sad.” Anxiety was cross-associated with the physiological themes of relaxation and muscular tension reduction: “It made me less anxious and a bit more relaxed and less tense”. Anxiolytic effects were commonplace, however some found that their anxiety had not changed or were unsure about any change: “There’s been no change” and “It maybe changed”. For those patients who did experience an anxiolytic effect, such anxiety reduction enabled a change in mood in response to the intervention, and one patient commented that “It lessened your anxiety levels, because if you and your mind are more relaxed, you’re less anxious...It definitely relaxed me, therefore my mood lifted”.

Positive change in mood was a key theme, with patients commenting that “it makes you happier” and “It lifts your mood right up and makes you more relaxed, less tense”. The intervention was found to be uplifting and induced equilibrium in mood state, by balancing out moods, for example, “I would think that if you’re upset, you’d feel much calmer” and “It depends on what mood you are to start with. If you’re low to begin with, it keeps you steady. If you’re feeling great, then it lifts you even more”. Mood improvement was also associated with having the ability increase the sense of agency in treatment, a serious concern for patients, for example, “There are times when you feel anxious, especially at the loss of control”. In a clinical setting where the patient has minimal involvement in decision-making and choice of care, using a music/noise-reducing intervention allowed the patient to impact upon their own treatment. Patients found that “It was good because you’re doing something to help yourself”, “...it made me feel good and useful...” and “It made me think and say ‘get a grip of yourself’ ”.

The final psychological theme concerned privacy and mental breaks. Patients enjoyed the opportunity to take a break and have ‘individual-time’ on a daily basis. Such a break enabled the participant to become removed from the ward and that was posi-

tively received, for example “I live on my own, and coming into a ward environment was hard for me. Fifteen minutes of privacy was good”. The intervention seemed to promote relaxation and this was associated with a short period in the day to have a break; “It’s the one calm period in the whole day. I look forward to it, and will carry on doing it at home”. Though some enjoyed the privacy, many also reported a theme surrounding the concept of attention. Being involved in the study meant that they had a period in the day of one-on-one attention and company and this was appreciated: “I enjoyed meeting you”, “It made me feel special for a brief period in the day” and “I enjoyed doing it, meeting someone and having the company”.

### **7.11.3 Methodological Category**

#### **7.11.3.1 Non-interventional**

In the course of the study patients made observations regarding the study and the methodology of the research. These comments were gathered together as dominant themes in the methodology chapter. The first methodological theme is that of location. Patients related two location-specific themes of concern: type of hospital bay and movement between wards. Firstly, patients reported increased satisfaction if they were placed in an individual room as opposed to a four-bed bay. Allocation was random, however those patients who did have a personal room were keen to mention the benefits of such: “I am very happy having a room on my own”, and “It’s great having a room on your own”.

In order to maximise the number of beds available on a ward, some patients were transferred between wards or nursing bases in the course of their recovery. This resulted in negative responses on the part of those patients who had been moved: “I was feeling very frustrated last night as a result of the move to Ward 203. The other people were unpleasant, and I had little support in the transfer or advance notice.” and “I’ve moved [nursing] bases too and I’m frustrated by that”. Frustration was a key emotion in movement-related themes. Transferring beds and bases also had an impact upon quality of sleep; “I didn’t sleep too well last night as my bed was moved to a different ward. But hopefully I’ll be home tomorrow”.

#### **7.11.3.2 Intervention-specific**

A further primary consideration was that of interruptions and distractions occurring in their study session, for example, “There was a lot of noise during the listening

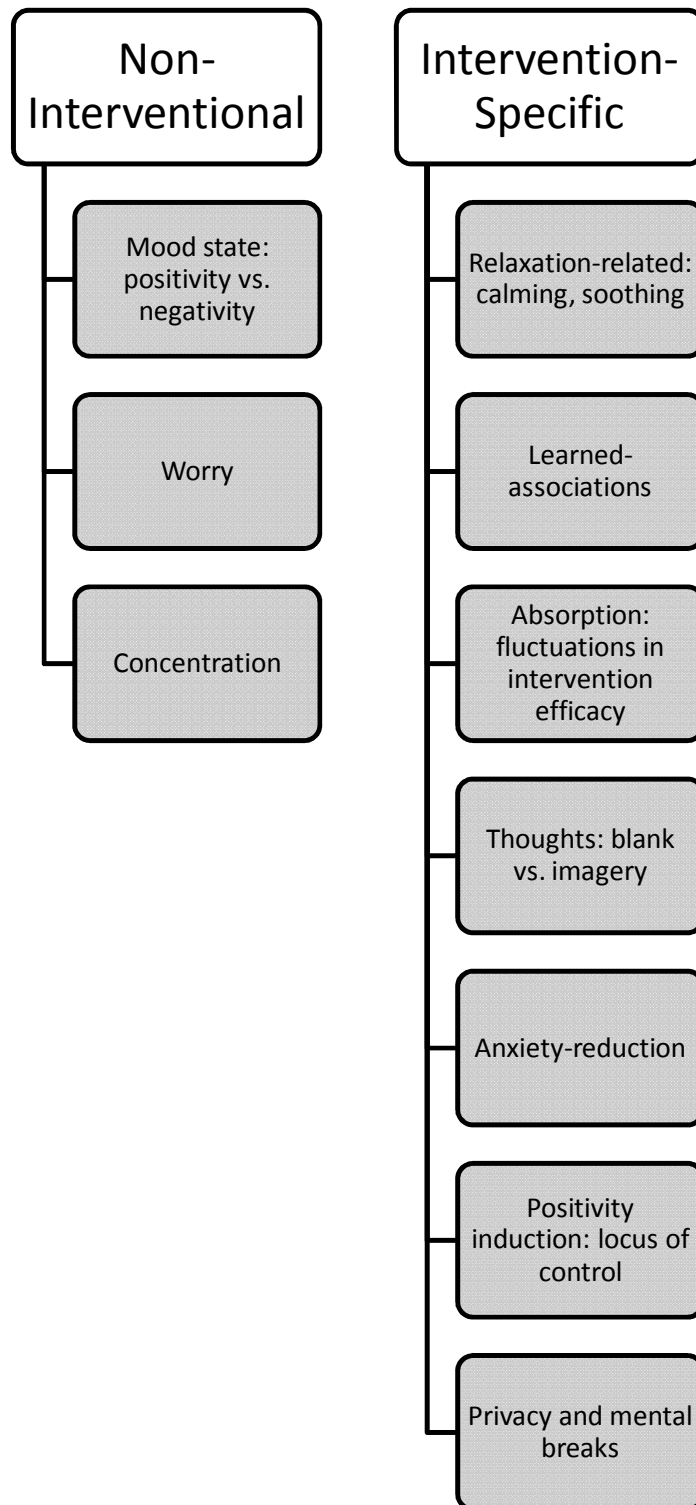


Figure 7.22: Contributing themes towards the emergent Psychological Category



as discharge/admission phase in ward” and “I was disturbed twice”. Consequently, patients remarked that “It was hard to tell whether it worked or not. I would need a few more days with no distractions”. Uninterrupted time was considered important and patients who were disturbed found that it hindered their ability to focus and benefit from their intervention: “When you link up with the music, it pervades the body and it really is lovely, like how you would think about a nice dream. I had two interruptions though today, and my train of thought was aggravated about three times and I lost it”.

The concerns around interruptions also centred on a theme of breakthrough sound, when the ward noise was audible during the intervention period: “The music was not quite as relaxing as yesterday. There was quite a lot of ward noise breaking through.’. Patients commented that: “I was able to switch off a little bit. I could still hear everything, but it was not as loud as usual” and “There was a fair bit of noise in the room and it was quite distracting—about 25% breakthrough”.

Two specifically study-oriented themes arose: technical difficulties and completion issues. The emergent theme of technical problems was principally concerned with the CD-player, for example, “I think there was a slight jump in the CD towards the end”. Though operating the CD-player was not required by patients, some still altered their intervention: “I got confused by the CD and didn’t listen all the way through and stopped it and fast-forwarded it”.

Patients were also concerned with their ability to complete the assessment, in relation to the saliva sampling and questionnaires. Some participants also found completing the voluntary salivary cortisol sample difficult and commented that, “I didn’t like the spitting. I found it very, very hard. The more I thought about it, the worse it got”. Regarding the questionnaires, patients commented that: “It was quite difficult to fill out the questionnaires” and that “Your questions are not the right questions. It is the same pain all the time. The questionnaire was too long-winded with too many questions”.

A key theme of importance to patients was that concerning assisting others. Participants felt that they were pleased to benefit future patients by assisting with the research and this impacted upon their involvement. Comments consisted of statements such as: “I liked the fact that you might possibly be helping someone in the future” and “It’s like putting back into the community”.

A further theme surrounded future research ideas. Participants suggested that additional time with the intervention would be useful, for example “...perhaps one hour per day”, that the intervention could be more regular, such as the comment that “It would

have been useful to have been able to use it more than once a day” and that it could be used at different times of day, “It’s a pity they don’t give you that at night. You should use it at night”. Finally, patients suggested that they may have enjoyed a change in the music, for example, “I might have liked a change of music everyday” or to have been given the opportunity to choose their own music: “If you bring your own music in, or the type of music you prefer, it would help”.

#### **7.11.4 Musicological Category**

For those participants who were allocated to the musical intervention groups, a number of themes were generated, giving rise to the musicological category. Of first priority for the participants was their liking for or disliking of the music. Participants who enjoyed their music commented so: “Lovely, lovely music, it was very soothing ” and “I enjoyed the music. It was beautiful...”. Patients who liked their music often chose to verbally validate their choices, asserting their feelings that they chose correctly: “The selection was chosen by myself and was very good, not too heavy”, “I’ve heard that type of thing before. I picked it because I think it is the type of music you would pick to listen to if you were in pain” and “It’s definitely the type of music I’d pick. I like to listen to music, even at home—soothing music”.

Those patients who enjoyed their music referred to the theme of anticipation—they looked forward to their music listening sessions: “I was really looking forward to my music today”. By contrast, a few patients stated that the music was not ‘their type’ of music: “It’s not something I’d buy, but I wouldn’t turn it off if it came on the radio! I wouldn’t close the door to it”. Musical preference was therefore a key theme for participants.

Accompanimental to musical preference were changes in the participants enjoyment/dislike of the music as the study progressed; this theme is termed familiarity-complexity. Essentially as patients became more familiar with the music, it became less difficult to understand and more accessible, enjoyable and beneficial: “You understand the music a bit better”. As they heard too much of the music, they became over-familiar with the music and it was essentially too simplistic and minimally stimulating for them, thus boredom ensued. Patients expressed this theme in two directions, as expected. Patients liked the music better as the study progressed: “I was apprehensive at the start about whether I would enjoy it or not. I don’t normally like modern jazz. I picked it though, and after the first time it got better and better”, and “I enjoyed

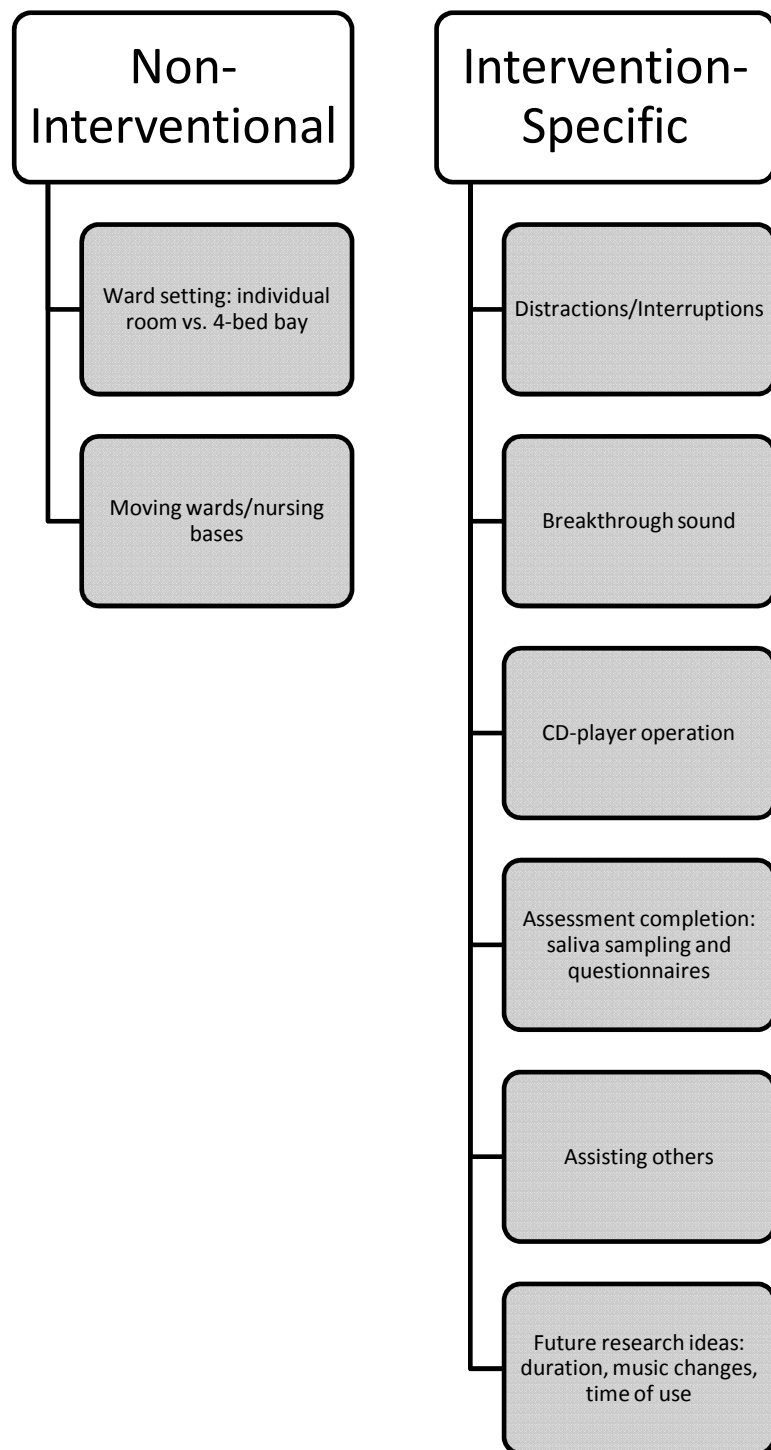


Figure 7.23: Contributing themes towards the emergent Methodological Category

it today [Day 3]. I had a chance to get into it today and was picking out the sound of the harp. The first two times it kinda washes over you. Then as you know more you see new things, like if you watch a film a few times". Similarly, patients commented that: "I think it's 'growing on me'" and "The more you get to know it, the more you drift away". When overly familiar with the music, patients noted that: "My liking for the music got gradually less each day", "The music sounded soothing, but I was really quite indifferent today; I suppose I've heard it quite a few times now" and "I got a bit bored of the music actually".

A theme of compositional constructs was of interest to participants. Participants commented on the musical form of the piece which they were listening to and stated that their knowledge of the music increased as the number of hearings rose. Participants referred to instrumentation, such as "I like the instruments in it actually, the strings and the piccolo", to the composers, for example "I like virtually everything Mahler has composed" and to the structural design of the music, such as, "Some of it was nice, but other sections were a wee bit thumpy". As they got to know it better, they commented more perceptively about the composition: "I liked the variety and change of keys and moods. I became more familiar with it as the week went on, and I was waiting for entries [of musical instruments]".

The volume of the listening was also important and enabled or diminished enjoyment, for example: "That sounded a bit better today because it was a bit louder", or "The music was too noisy. I really just wanted to take the headphones off".

Those patients in the musical intervention groups as well as those participants in the control group mentioned a theme of 'quiet'. The control group found that: "You just seem to be able to switch off to the noise and the surroundings. I think it's just the silence that is so relaxing" and "It's been lovely, so much quieter than normal". The music groups reported that, "The music reduces the noise. With so much going on in a ward, you get tired taking things in, your mind has to concentrate a lot, and the music was a break from all that" and "It's been very pleasant and I've enjoyed the quiet very much as that's my style". Quiet and the reduction in ward noise was therefore an important and universal theme for all patients.

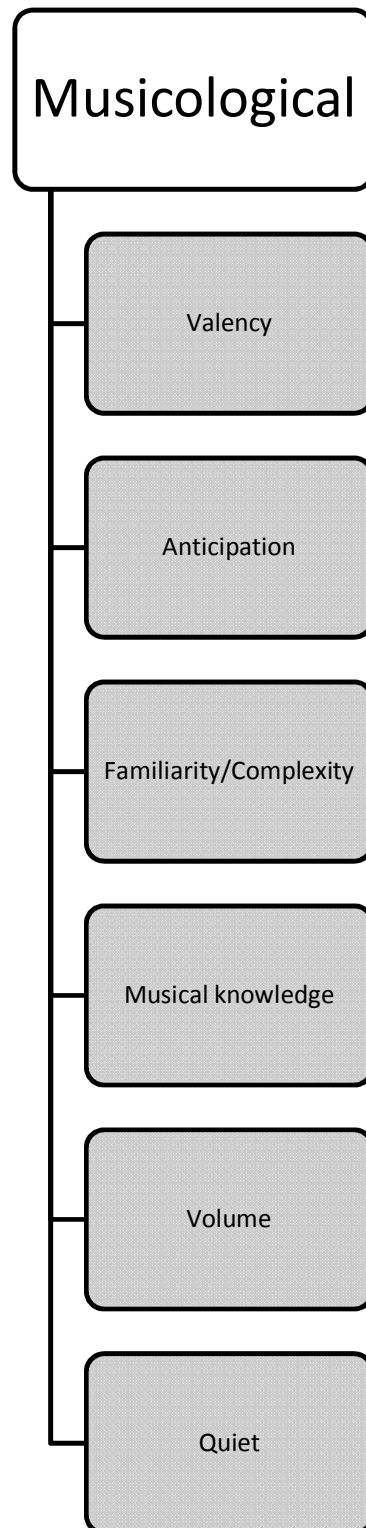


Figure 7.24: Contributing themes towards the emergent Musicological Category

# Chapter 8

## Discussion

### 8.1 Primary Outcome Measures

It was hypothesised that as a result of the activation of cognitive-coping strategies through the intervention, post-test Total Pain Scores would be lower than pre-test scores on the Short-form McGill Pain Questionnaire. It was expected that this would of greatest magnitude for the experimental group participants. However, results show that there was no significant difference between groups in the pre- to post-test pain reduction. All groups showed lower post-test scores and this change attained the boundary necessary for an indication of clinically meaningful change (mean 32.91% change in this study). The ++ group did not achieve the greatest reduction and the results suggest that there was no difference between groups as a result of MMCR category. Harmonicity and rhythmicity did not affect Total Pain Score. As expected, however, Total Pain Score was at its highest level immediately post-surgery and it did decline across the course of the study.

In assessing functional impairment as a result of post-operative pain, results showed that all patients exhibited high levels of Pain Interference on assessment at their Pre-admissions Clinic. This indicated that surgery was an appropriate course of action for participants as their functional abilities had declined significantly pre-operatively. Maximal pain interference scores registered on Day 1, the first day following surgery, and they declined by Day 3, and remained approximately at this level through to Day 5. The results on Days 3 and 5 were below those from the Pre-admissions Clinic, suggesting that even shortly after arthroplasty surgery, post-operative functional ability was improved from pre-surgical status. There was no difference between groups on any Day of Testing, though not all groups showed the same patterning in their changes

across time. The ++, +- and -+ groups showed inverted-V shaped changes over the course of the study, peaking on Day 1, whereas the control group and -- group showed gradual declines throughout. As the Brief Pain Inventory was not recorded pre- and post-intervention, and given that the overall results did not show a significant difference between groups, it is unlikely that this interaction is directly due to the auditory interventions. Pain interference is indicative of pathological difficulty as a result of functional impairment in the action of the joint. Thus the discrepancies between groups in their improvement in functional ability likely reflects slight differentiations in the way in which patients responded to their surgery and the degree of proprioceptive inhibition that occurred immediately following surgery and not in response to Group Allocation as overall there was no significant difference between groups.

It was next hypothesised that surgery would cause a leap in Cortisol Concentrations. The results show that Day 1 exhibited significantly higher Cortisol Concentrations than those of the Pre-admissions Clinic. The surgery was therefore a clinical stressor of sufficient magnitude to cause a large stress response. After Day 1, Cortisol Concentrations declined across the course of the study, reaching a level from Day 3 onwards which was below that of the Pre-admissions Clinic. The pre- to post-test analysis showed that there was no significant overall reduction in post-test scores following the intervention, suggesting that the auditory interventions were not successful at reducing endogenous cortisol levels in the course of the 15 minute relaxation period. The investigation into between-group differences confirmed that there was no difference between groups on Days 2–5 of Testing. On Day 1, however, the ++ group showed a reduction in pre- to post-test Cortisol Concentrations, whereas the Concentrations in the -- group went up. The music with high harmonicity and high rhythmicity had a greater role in modulating the production of cortisol by the HPA axis than music with low harmonicity and rhythmicity. It is notable that this difference was only present on this first Day of Testing and there was no greater magnitude of change for the experimental groups over the control group. This suggests that the effect of musical constructs on Cortisol Concentration was not enduring and did not markedly affect Salivary Cortisol.

The act of undertaking surgery did cause Mood Disturbance for all patients. Just as functional recovery and pain levels reduced and improved with time, so did mood state. By Day 3, the level of Mood Disturbance was significantly lower, but had not yet returned to pre-surgical levels. There was a slight rise in Mood Disturbance for the remaining patients on Day 5, but it is not possible to offer more than a speculative

reason for this increase (see page 203).

To summarise, the results of this study showed that the primary outcome variables on the questionnaire measures demonstrated no consistent differences between groups. Functionally, patients attended hospital having experienced a relatively high levels of pre-operative functional impairment. Following their total knee arthroplasty, patients demonstrated excellent rates of functional recovery and by Day 3 post-operatively, functional impairment was at a lower level than before surgery. The surgical intervention was highly effective at promoting better functional outcomes for patients and that this effect was durable and meaningful from Day 3 onwards. The results concerning pain levels showed that all patients experienced significant reductions in their pain scores after the fifteen minute period of the relaxation intervention. There was, however, no significant differentiation between the experimental and control groups, indicating that harmonicity and rhythmicity did not impact upon the primary outcome variables testing in this study. Although there was no difference between control and experimental patients, the fact that the pain reduction attained the level recommended by the IMMPACT task force for moderate clinical meaningfulness is important. Thus, the psychological methods of pain control used in this research study had considerable potency in the reduction of post-operative pain.

## 8.2 Secondary Outcome Measures

It was found that the effect of the intervention was time-limited, and that there was no impact of music listening on VRS/NRS scores. There was no difference between groups at any point of testing: control and experimental group participants responded similarly on their subjective pain ratings and their scores were not affected by their Group Allocation. In general, pain scores on movement were significantly greater than pain scores at rest. The action of flexing and extending the knee required the participant to mobilise the new knee joint and the injured tissues surrounding the knee, thus pain was elevated. Contrary to the hypothesis, however, pain was in fact greater in the morning than in the evening. The implication of this finding is that the prolonged period of inactivity at night resulted in greater pain and stiffness in the morning, than was caused by a full day of activity during which the knee was kept mobile.

Investigating the subscales of the Brief Pain Inventory, there was no difference in results between control and experimental group participants. The ++ group did not show greater reductions than the -- or control groups. The highly subjective



dimension of Worst Pain showed improved (lowered) ratings as health status stabilised in the days following surgery. Mean Pain did not respond in this way, indicating it was less subjectively primed in its rating. Perceived Pharmacological Pain Relief was poorest at the Pre-admissions Clinic when patients were expected to manage their pain independently. Even after invasive surgery, Pharmacological Pain Relief still improved from this baseline, with an rise by Day 1 and again by Day 3, demonstrating that the analgesia provided in hospital was perceived of as highly effective by patients. Though a significant number of participants were discharged by Day 5, those who remained showed the expected pattern of a drop again in Pharmacological Pain Relief. This was due to reductions in the potency of the analgesia in order to provide the participant with drugs that could be managed independently in a familial setting after discharge. These findings indicated that pharmacology was most effectively managed within an in-patient setting.

The subscales of the Short-form McGill Pain Questionnaire did show a response to the silent and music listening interventions, with a significant reduction in pre- to post-test scores: all dimensions of the SF-MPQ showed lower post- than pre-test scores. It was hypothesised that the psychological resonance of the intervention would reduce Affective pain more than Sensory pain. The results confirmed this, and the magnitude of change from pre- to post-test was greater for Affective than Sensory pain. Contrary to the hypothesis however, the subscales did not show any difference between groups. The control intervention was therefore as effective as the music listening intervention in pain reduction. There was, however, a significant interaction on the Present Pain Index dimension between Group, Day of Testing and Time of Testing. This indicated that the change on Day 1 was greatest for the + – group and that the lowest performers were the + + and control groups. Where the + + group displayed low change scores on Day 1, they rose by Day 2, whereas the + – group started with a high rate of change and this declined as the study progressed. This result suggested that there may be some active function of compositional construction on the familiarity with and efficacy of the music (see page 220 for discussion), though this was not to such an extent that a robust significant difference between groups was found.

The POMS assessment also showed that there was no difference between groups on any of the sub-dimensions: the music listening intervention did not improve long-term mood stability for any group of participants over another. It was hypothesised that scores would peak on Day 1 and improve by Day 5 for five of six dimensions; Tension–Anxiety, Depression–Dejection, Anger–Hostility, Fatigue–Inertia and Confusion–Bewild-

erment. This was upheld for all except the Anger–Hostility dimension. The Anger–Hostility dimension instead showed a drop in scores on Day 1 and a rise throughout the study. This showed that participants were least angry/hostile on Day 1, but felt increasingly more angry and hostile as the study progressed. The Vigour–Activity dimension also showed a drop in scores on Day 1 and a steady rise throughout the study. This was because functional impairment is at its greatest on Day 1, so Vigour–Activity is inevitably low. Functional Ability improves as pain and inflammation decreases as the days pass, thereby increasing Vigour–Activity scores.

To review these secondary outcome measures: it was found that there was no difference between groups on any assessment measure. All control and experimental groups responded similarly in their pain, function and mood states. The only exception was the discovery of an interaction between groups and the day of assessment on the Short-form McGill Pain Questionnaire. This finding suggested that familiarity with the musical stimulus may differentially impact upon the patterning of pain reduction. Subjective pain ratings showed that pain was greater in the morning than in the evening, and this was thought to be related to the stiffness induced by inactivity during the night. The Worst Pain subscale of the Brief Pain Inventory was found to improve as health status stabilised post-surgery, but Mean Pain did not reflect this pattern, suggesting that the highly subjective requirement of a ‘Worst Pain’ judgement is more sensitive than the Mean Pain measure. Perceived Pharmacological Pain Relief was found to be poorer in the familial setting than in hospital, and the pharmacology was considered less effective as the opiate-based analgesics were changed to non-opiate-based medications in preparation for discharge. Patients’ mood stability improved as the days passed post-surgery, and all sub-dimensions of the Profile of Mood States questionnaire performed as expected, except the Anger–Hostility dimension. This rose instead of decreasing as the study progressed. It is likely that this was in response to frustration at remaining in hospital when discharge was expected. Qualitative data is reflected upon on page 203 in discussion of this explanation.

### **8.3 Implications of Research Findings**

The results from the quantitative study have been clearly outlined above, but questions remain surrounding how these findings relate to the themes that have arisen through the qualitative analysis. Similarly, it is important to note what the resonance of the results are in light of contemporary literature. Thus this section will strive to answer

these pertinent questions. Firstly, the results of the qualitative analysis will be used to provide additional clarity in the discussion of the quantitative findings. Findings will be outlined in reference to the categories emergent from the thematic category analysis and comparisons will be drawn between the qualitative and quantitative results. Following this, the results will be related to the literature contained in Chapters 2–7 and to recent research studies. The methodology category will be referred to in discussion of limitations of this research.

### **8.3.1 Physiological Category**

#### **8.3.1.1 Pain**

Looking first at pain, both quantitative and qualitative results confirmed that patients undergoing Total Knee Arthroplasty did suffer from significant pain and were knee replacement patients were therefore a rational choice of patient population for this research. Patients reported experiencing severe pain, particularly in the early post-operative period. Previous research substantiates this and has also demonstrated significant pain following arthroplasty surgery (Lingard and Riddle, 2007; Parvataneni et al., 2007b). When pain is so severe an adjunctive treatment, as used in this research, is a viable addition to the standard care programme. This study was therefore a valuable intervention with a vulnerable patient group. The high levels of pain experienced in the immediate days post-surgery did not endure for all patients throughout the entire study. By Day 3, qualitative data revealed that many participants felt that their pain had improved, and this validated the finding of the Short-form McGill Pain Questionnaire, on which the greatest improvement in pain was shown on Day 3. This finding reiterated the importance of effective pain management in the early post-operative period, and also indicated the speed at which the body recovered following the surgery.

The interventions used in this research did engender pain relief. Quantitative results from the Short-form McGill Pain Questionnaire showed that there was a significant improvement from pre- to post-test for all participants. This improvement was of a magnitude great enough to be clinically meaningful, and pain was reduced by approximately one-third in the course of the fifteen minute intervention. The size of this reduction, yet the finding that there was no differentiation between experimental and control groups suggests that the intervention may have shown a placebo effect. This will be discussed in the limitations section (see page 222). Despite the lack of between-group difference, the pain reduction shown in the quantitative findings is at

odds with some of the qualitative findings. Where quantitative data showed an overall improvement in pain levels, qualitative data stated that the the relaxation intervention used in this study was effective at reducing pain for some participants, but this outcome was heterogeneous. Though some patients felt that their pain had been completely removed by the intervention, others stated that there had been no impact. Why did this quantitative-qualitative divergence occur? Whilst it is important to have demonstrated quantitative changes, the subjective viewpoint of the patient is also paramount when evaluating the efficacy of a treatment. As outlined by Melzack (1983), pain is best understood by the person experiencing the pain. The contradiction that was shown for some patients was related to confusion surrounding themes of ‘actual’ versus ‘perceived’ pain relief.

Patients differentiated between ‘actual’ pain relief which was thought to be the result of clinician-prescribed pharmacology, and ‘perceived’ analgesia which was that provided by any other form of intervention, including that used in this study. Whilst patients felt that their pain levels could be and were changed by both contexts, where the pain reduction was attributed to ‘perceived’ pain, this was thought to be only a masking of the ‘actual’ pain which remained undetected underneath. In this way ‘actual’ pain was defined as physical changes in the sensory dimension of pain and ‘perceived’ pain as specific psychological bolstering. Such psychological bolstering was thought to mean that patients’ perceptions of the underlying ‘actual’, sensory pain was reduced. Psychological improvements were therefore attributed to affective *feelings* about pain rather than to pain itself. There was no recognition of the concept of ‘affective pain’: the affective changes were feeling-related and not pain-related. Where sensory and affective dimensions were both reduced, sensory pain was primary and and affective secondary. Sensory and affective pain were singularly divided in the minds of patients, with sensory pain most salient.

This perception contradicts the widely-accepted and well-validated concepts of contemporary pain theory. The relationship between biological, psychological and sociological dimensions was formalised in the biopsychosocial model of pain (Engel, 1977). Through this model, it was theorised that all three dimensions had the potential to contribute to pain modulation. The gate control theory of pain empirically reflected this by asserting the importance of environmental and personal factors in contributing to the modulation of afferent impulses in the dorsal horns of the spinal cord. The neuromatrix theory of pain postulated the existence of three different parallel processing networks through which pain signals are parsed by the central nervous system:

sensory-discriminative, affective-motivational and cognitive-evaluative systems. The biopsychosocial model, gate control and neuromatrix theories of pain all validate the potential of non-pharmacological stimuli to modulate pain. That the intervention in this study undoubtedly had the potential to be active across the three dimensions and three networks was justified in chapter 3. Quantitative research using the Short-form McGill Pain Questionnaire confirmed this. An overall improvement in Total Pain Score was found, but also concurrent changes in the sub-dimensions of the questionnaire: sensory and affective pain.

Both sensory and affective dimensions showed pre- to post-test reductions in their scores. This therefore indicated that the music listening or quiet intervention did resonate biologically (sensory pain) and psychologically (affective pain).<sup>1</sup> If sensory pain is considered ‘actual’ pain and affective pain as ‘perceived’ pain, then quantitatively the intervention was meaningful in both ways. In fact, the magnitude of change on the affective dimension was slightly greater than that on the sensory dimension, suggesting that reductions in ‘perceived’ pain were as robust as and complementary to improvements in ‘actual’, sensory pain. As the intervention was largely a psychological intervention, the greater reduction in affective pain over sensory pain is line with research by Eccleston (2001) who confirmed the significant contribution of psychological approaches to pain management, particularly for affective pain reduction. Stevenson (1995) also asserted the ability of distraction methodologies to impact upon the affective distress component of pain—the results of this study validated this finding, and the interventions successfully reduced both affective and sensory pain.

Considering this qualitative dyad between actual versus perceived pain relief, patients predominantly viewed their pain relief in light of the sensory-discriminative dimension of pain. Yet research has repeatedly shown the importance of affective-motivational and cognitive-evaluative systems in the modulation of pain signals. Neuromatrix theory specifically integrates a highly personal neurosignature through which pain is modulated. The neurosignature is genetically pre-conditioned, but patterned by experience. Every previous pain event, past experience with noxious stimuli and personal response to pain modifies the neurosignature. Pain is rarely affectively neutral: affective perceptions of a pain event impact upon how the person will respond to pain on encountering their next painful event, be it serious or inconsequential. Thus it is important that patients recognise that actual pain relief can also be achieved non-

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<sup>1</sup>The impact of the intervention on the sociological dimension will be discussed subsequently, see 8.3.2.5.

pharmacologically. The qualitative results of this study demonstrated that patients do not have confidence in this regard.

Western medicine generally operates through a biomedical approach to pain and it was this perception that was embodied in the qualitative results. It seems that this viewpoint was entrenched and patients found it difficult to conceive of how a non-pharmacological intervention could be beneficial. The bio-bio-bio concept of pain (see Sharfstein, 2005) is therefore not just a challenge to medical practitioners, but also predominates in the mentality of patients. It should be noted that this does not encompass all patients, however, and many found the intervention effective. Previous research has demonstrated that educating patients about pain and how it is processed could facilitate greater understanding of how to contribute to one's own care, using adjunctive treatments to improve pain state (Good, 2008). Emery et al. (2006) showed that even a short time spent educating patients about their pain, surgery and teaching the methodologies used for increasing cognitive-coping can reap significant benefits for patients in the degree of pain which they experience and the way in which they cope. Future research and clinical practice could aim to increase patient education.

A further theme generated by qualitative research stated that the durability of the benefits of the intervention were of concern to patients. Despite music's potential relevance as a long-lasting, tonic modulatory stimulus, qualitative data seems to suggest that it is in fact more phasic in its effects. Some patients felt that the pain modulation was only for the time-span of the intervention. For these patients, pain was thought to return immediately after the intervention was completed. For others, the effect endured for slightly longer, approximately 5–10 minutes after the intervention, or until the patient moved their knee in anyway. A third group of participants felt that the intervention had the potential to be beneficial for a greater time-period, particularly if they remained undisturbed post-test. Quantitative data showed pre- to post-test improvements in pain levels, but no change in the morning and evening VRS/NRS measures. Pain reduction therefore did not last across the intervening period of hours from the afternoon intervention session to the pain assessments in the evening or following morning. The intervention was therefore time-limited, as qualitative data asserted. This contradicted the findings by McCaffrey and Freeman (2003), where music listening with chronic pain patients showed a cumulative increase in pain relief. Acute pain does not respond in this way Future research could clarify how long the analgesia persisted by undertaking more frequent pain assessments, and could compare the effect of an intervention between acute and chronic pain sufferers.

There has been little research assessing the durability of audio-analgesia and this is an area which needs consistent work in the future. Applicable research has shown that the mood changes induced by music are short-term. Panksepp and Bernatzky (2002) asked sixteen college students to listen to 40 minutes of happy or sad music and assessed the longevity of music-induced mood changes. Music did correctly induce the desired moods (e.g. happy music induced a happy mood) and this effect was strongest immediately after the music. The induced mood was still significant at 10 minutes post-intervention, though it had diminished. At 20 minutes after the intervention; however, the mood state was no longer empirically evident. Music therefore influenced mood, but this did not extend post-listening for longer than 10 minutes. If the results of this study were applied to pain, then this would suggest that the post-test SF-MPQ data was taken at the peak of the response to the intervention, but the analgesic effects would thereafter have declined quickly, hence they were not reflected in the morning and evening pain ratings. Certainly further research is needed to clarify this area.

The results in this study show that there was short-term reduction in pain states as a result of the intervention. This finding was in confirmation of the body of work by Professor Marion Good, who demonstrated extensive reductions in pain for large samples of participants (see Good et al., 1999, 2001, 2004, 2005; Good, 2008). Yet it contradicts the recent findings by MacDonald et al. (2003) and Ikonomidou et al. (2004) whose research showed no change in pain levels. Both studies worked with gynaecological patients, and it is possible that the inter-group dynamics of the gynaecological population renders a music listening intervention inappropriate. MacDonald et al. (2003) outlined how gynaecological patients supported each other in the ward setting and how group cohesion was particularly important given the highly affective nature of the surgery. In this context, the music listening intervention may have been negatively received as it isolated the participant from their peer support group. The study also did not use a pre- and post-test assessment design, which may mean that due to the time-limited effects of the music-listening intervention, changes in pain intensity did not register. Future research into the durability of audio-analgesia with different patient populations would clarify whether this may explain the difference in results.

Mitchell et al. (2006), whose research with cold pressor pain did use a pre- and post-test assessment design, found changes in pain tolerance but not pain intensity as a result of a preferred music listening intervention. This thesis analysed pain on different dimensions, but did not assess pain tolerance. Tolerance of pain is difficult to appraise

with a clinical population as there is no standardised end-point: pain must be tolerated throughout the period of recovery until improved health status means that pain signals cease. It is complex, therefore, to identify a marker of good pain tolerance versus average or poor pain tolerance. It is in this context that pain behaviours could serve as signatories of pain tolerance. The qualitative responses of patients in this thesis and anecdotal observations, suggested that patients exhibited pain behaviours in their early post-operative recovery period. These behaviours were evident to the experimenters, and to the participants themselves: wincing, groaning, rubbing the injured knee, limping and significantly slowed ambulation. Observational methods have been used to rate pain intensity and pain behaviours, and this methodology could be applied as a marker of pain tolerance in future research (following McDaniel et al., 1986). That patients demonstrated pain behaviours, is confirmation of the intimate connection between pain and movement and the subjectivity of behavioural responses to pain. Future research could assess the differences in behavioural responses to pain in chronic versus acute pain.

Qualitative data also noted that the music listening intervention caused patients to experience an impetus to move. Patients expressed surprise at the fact that they were tapping their foot on their post-surgery leg. This indicated the strength of the theoretical stance that music can activate movement patterns. Qualitative data showed that patients particularly experienced shooting pain, stiffness and swelling throughout their recovery. Quantitative data found that pain was worse in the morning than in the evening. This is important as it demonstrates the impact of prolonged inactivity (through the night and whilst asleep) on pain. Pain in the evening was lower after a day in which the knee was kept mobile through physiotherapy and daily activity. The use of music as a method of improving and inciting mobility is therefore key not just as a therapeutic cue, but also as a way in which activity can be promoted and pain and stiffness therefore minimised.

Ultimately, to consider the research that exists in the field of audio-analgesia and that has been reviewed in this thesis, it is difficult to generalise the results of studies into laboratory-induced pain with healthy participants to research in a clinical setting. Laboratory-induced pain cannot effectively incorporate the affective quality of pain to the degree that clinical pain represents. In a clinical setting following illness or invasive procedures, anxiety, depression and health problems mean that participants are more vulnerable than in a non-medical setting and thus laboratory-induced pain cannot fully reflect the complex responses resulting from clinical pain (MacDonald



et al., 2003). Whilst laboratory-induced pain cannot reflect the fullness of clinical pain, it does provide insights into generalised pain responses. Future research could perhaps therefore take a two-step approach. Interventions could be trialled with both healthy and clinical participants where appropriate. This would facilitate greater knowledge of the intervention and would highlight any conflicts between experimentally-induced pain responses and clinical pain.

### **8.3.1.2 Functional Ability**

Few patients remained in hospital for the total duration of this research. This shows that the care pathway utilised by the hospital was effective in mobilising patients post-operatively and in improving their health-status enough to enable them to continue their recuperation in their home environments. The important finding that by Day 3 of testing the functional ability of patients had returned to below pre-surgical levels, was indicative of how critical arthroplasty surgery was for these patients. Pre-operatively, arthritis sufferers often demonstrate impaired proprioception that can cause them to stumble, fall and find ambulation difficult (Kidd, 2006). Yet the quantitative results from the Brief Pain Inventory demonstrated how effective arthroplasty surgery was at enabling patients to regain functional ability. Shortly after surgery, patients felt that their functional impairment was lower than that experienced at home pre-operatively. Total Knee Arthroplasty, at Level 5 of the pyramidal approach to osteoarthritic pain management (see page 19), is an invasive procedure which invokes acute post-operative pain, particularly on ambulation (Dennis, 2004; Lingard et al., 2004). Majewski et al. (2005) found that Total Knee Arthroplasty improved proprioception for arthritis sufferers, and whilst proprioception was not directly surveyed in this study, the significance of the improvement in functional ability suggests that the surgery has considerable benefits for patients in all aspects of movement. The consistent quantitative improvement shown in this study offer confirmation that function becomes easier post-operatively for patients.

The concomitant psychological impact of functional improvement is not to be underestimated, and it is likely that after successful surgery, patients would have better mental health status and be able to return to their hobbies and social circles (Lingard and Riddle, 2007; Wright et al., 2004). Optimising pain control is a primary factor in the speed at which patients return to normal function, earlier mobilisation and proficient ambulation (Lingard et al., 2004). As the intervention used in this study successfully reduced pain and promoted movement, it is a beneficial addition to the 'kit'

approach of optimal multi-modal post-operative care.

### 8.3.1.3 Sleep

Qualitative data throughout this study asserted that sleep was a primary concern for participants. Participants found that their sleep was repeatedly disturbed by their pain, by noise or the combination of pain and noise. Lack of sleep and disturbances during the night caused patients to feel exhausted and this impacted upon their ability to cope and their perceived rate of healing. A large proportion of the qualitative responses from patients in the physiological category related to sleep and concerns surrounding lack of sleep. Sleep was undoubtedly of paramount importance to patients. Other research has confirmed that sleep quality can impact upon recovery rate. Good et al. (2002) investigated pain and sleep quality in gynaecological surgery patients. Those participants who had a poor night of sleep had significantly elevated pain during the day following the disrupted night. Poor sleep preceded greater pain, but pain did not predict poor sleep. Sleep quality was therefore directly proportional to the ensuing levels of pain experienced by patients. The qualitative responses of patients in this study validated this and reiterated the fundamental human need for good quality of sleep.

In confirmation of the problems caused by sleep disruption, a large proportion of patients fell asleep during their 15 minute intervention. Poor night-time sleep inevitably influences the numbers of patients who subsequently fall asleep during the intervention due to exhaustion and sleep-debt. Patients reported feeling refreshed and in better spirits after this short period of intra-interventional sleep. Some patients also stated that falling asleep in the daytime or whilst relaxing was not normative behaviour for them. Ethically, it was not possible to stop patients falling asleep during the intervention, but the fact that many did sleep remains an interesting finding. This result indicated both that patients were exhausted, and also that the interventions facilitated sleep. All music groups and the quiet relaxation control group were equally as affected by intra-interventional sleep, thus all types of music and quiet relaxation are able to promote sleep. Looking at sleeping as a result of a music listening intervention in particular, Good et al. (2005) also found that many patients slept during their intervention. Good et al compared the influence of music and jaw relaxation on post-operative pain following intestinal surgery. They found that of the patients in the music-related treatment groups (music, or the combination of music and jaw relaxation), 70% were asleep at the end of one or more of their tests. Rates of intra-intervention sleeping did

not reach that percentage in this study, but Good et al confirmed that sleep was not an abnormal response to the experimental intervention. Many studies into music and pain have not reported whether patients slept during their listening session, thus it is an area which needs further research. It is possible that falling asleep may contribute to a greater change in pain from pre- to post-test and more research is required.

Though whether patients slept or not is important in the interpretation of results, a primary issue concerns why patients' sleep was so disrupted in the first place. Quality of sleep is largely dependent on the suitability of the night-time environment. Qualitative results suggested that patients found their environment disrupted due to noise, pain and their combination. Though pain is an inevitable response to the invasive surgery, noise is problematic. The hospital environment may be viewed as one in which 'noise pollution' is rife. Noise pollution has been defined as an impurity of unpleasant sounds (Cabrera and Lee, 2000). With the beeping of monitoring machines and the activity of staff and other patients, noise levels are often high in hospital. The International Noise Council based with the Environmental Protection Agency in the United States have set guidelines for the noise levels in acute care areas of a hospital (including orthopaedics). Akin to a volume slightly lower than the sound of light traffic or slightly above normal conversation, daytime levels should be approximately 45 dB in the daytime and 20 dB at night (the volume of a quiet conversation) (Bayo et al., 1995). The reality has been proven quite different to the guidelines. Cabrera and Lee (2000) reported that the average noise level of acute care admissions wards at night was recorded at 67 dB.

The number of decibels on the orthopaedics ward at night was not recorded in this study, but qualitative data suggested that it was likely quite high. Patients reported hearing other patients shouting and snoring, nurses speaking loudly and machines beeping. The consequences of noise pollution are not insignificant. Noise pollution is thought to cause increased hearing damage, anxiety, loss of sleep, altered pain perception, hypertension, fatigue, irritability, prolonged convalescence and increased length of stay (Cabrera and Lee, 2000; Hilton, 1987). Further to the physical symptoms, cognitive ability is also affected by noise: task performance ability in adults and children deteriorates as a function of noise perception (Monroe, 1996). For a post-surgical clinical population, these factors are of significant concern to patients' rate of recovery physically, functionally and psychologically.

In combination with significant levels of pain, it is perhaps unsurprising that patients in this study struggled with sleep. Yet what can be done to minimise sleep disruption, and how can the interventions used in this research contribute to improved

sleep quality? Music amply masks the noise pollution from hospital equipment and activity and (as has been shown in this thesis) can have concomitant psychological, physiological and sociological benefits for the patient. Though it could be argued that using music would simply add to the noise pollution, in fact the opposite is true: music is thought to minimise noise pollution (Cabrera and Lee, 2000). Music and noise are acoustically different: noise is created by non-periodic, non-harmonic vibrations and music by regular, harmonically and rhythmically-induced periodic vibrations (Nattiez, 1990). If the music was sensitively chosen and given to patients for use on a personal music system rather than over loudspeakers (Muzak), then it could be highly beneficial. Patients in this study specifically requested the use of their music for the purposes of sleep-induction, thus qualitative results showed a role for music in the promotion of better sleep quality at night. In this context, music could function as an auditory block in the immediate period before falling asleep. Night-time is therefore a prime example of when music could aid patients with sleep.

Wholesale NHS-based changes would include creating hospitals with better acoustic noise filtration and changing out-dated hospital equipment to machinery that is quieter or has volume controlled beeps. Within the orthopaedic wards, this would particularly pertain to HR/BP machines, PCA providers and the foot circulation pump systems that are a daily part of life in recovery from orthopaedic surgery. There must also be some clinician re-education about the impact of noise on patient recovery. These are perhaps a long-term goals, but would make a viable difference to the sleep quality of many patients. In the interim period, however, music provides a widely accessible, financially viable and positively received intervention that could be utilised for noise control. As many patients requested the use of the music as an aid to sleep-induction at night, it would be useful to evaluate whether there is an optimum time of day during which a music listening intervention could be particularly advantageous to patients. Further research in this area would be highly salient to patients and would enable a greater understanding of how noise pollution and concomitant sleep deprivation interacts with recovery rate.

#### **8.3.1.4 Cortisol**

Investigating neuroendocrinology, the quantitative results of this study demonstrated that cortisol concentration did show a response to the surgical stressor. Concentrations increased immediately following surgery and decreased across the course of the study. Total Knee Arthroplasty surgery therefore was clinical stressor of high magni-

tude, as demonstrated by (Leopold et al., 2003). As such, the body was experiencing a significant stress response, the reduction of which was a valid target for clinical research. Looking next to between-group differences, a key finding in the domain of compositional constructs, was the demonstration of a significant difference in cortisol concentrations between groups on Day 1, with the ++ group showing greater pre- to post-test change than the -- group. This finding indicated that music with high harmonicity and rhythmicity had an advantage over music with low harmonicity and rhythmicity in the context of severe post-operative stress. ++ music facilitated greater activity in the HPA-axis which enabled a reduction in cortisol, whereas the music heard by the -- group led to increased cortisol concentrations from pre- to post-test. This was only operative on Day 1, however, suggesting that musical constructs only impact upon cortisol concentration in the period of greatest stress. Immediately after surgery, patients responded better to highly harmonic, highly rhythmic music than to music without an obvious tonal centre or pulse. This is likely to reflect music which participants are most familiar with: in a Western culture, participants have greater knowledge of and exposure to music which is typically ++, therefore the -- music was more unfamiliar and therefore potentially required time for patients to respond. The fact that the difference between groups was only shown on Day 1 would indicate that when the stress response was less severe and cortisol concentrations diminished, familiarity with the stimulus was not as important and participants responded similarly to all types of the intervention. A rationale for the familiarity response to music is given on page 220. Further research is required to investigate the role of compositional constructs on cortisol in the context of high versus low levels of stress.

Despite inter-group differences on Day 1, overall cortisol concentration did not respond to the intervention. There were no pre- to post-test reductions in cortisol concentration. The combination of these two findings seem to conflict: the between-group differences suggest that music does differentially impact upon cortisol, but the lack of pre- to post-test change would indicate that the intervention was unsuccessful. As there has been minimal research in this area, it is difficult to offer an explanation for this discrepancy. The fact that there was no change in salivary cortisol concentration is in confirmation of the recent findings by Good (2008). Over five hundred abdominal surgery patients either received music with relaxation, teaching about stress, the combination of music, relaxation and teaching, or standard-care (control). They were monitored for cortisol twice daily for two days post-operatively. Cortisol samples were taken before and after the intervention. Good et al found that as in this study, none of

the interventions reduced cortisol, though the relaxation/music intervention did reduce pain.

The finding that music listening does not reduce cortisol in the post-operative period contradicts the research into music and pre-procedural or laboratory-induced stress which showed that music did improve cortisol concentrations in that context (see Khalifa et al., 2003; Miluk-Kolasa et al., 1994). Hammerfald et al. (2005) showed that cognitive-coping strategies could be used to reduce stress and lower cortisol concentrations. It is important to understand why there may be this discrepancy between previous literature and current results. A primary reason may be that Total Knee Arthroplasty presents a significantly greater clinical stressor to the body than pre-surgical stress. As a consequence, surgery has a more prolonged and pronounced impact upon the HPA axis. The potential of music to reduce low-level stress should not be generalised to all possible forms of stress, especially high-level stressors such as pain-related stress following surgery. In evaluating stress-response studies (see page 35), laboratory-induced stress was vulnerable to a music listening intervention, but it is possible that clinical, pain-related stress is not affected. Cortisol is excreted due to stress and so it is logical to expect a change if the perceived stress is reduced. However, the insult to the body as a result of surgery or significant pre-surgical anxiety is perhaps too great for meaningful change precipitated by a short-term, time-limited intervention.

In addition, some research has shown that the relationship between pain and cortisol may not be as transparent as that between stress and cortisol. al' Absi and Petersen (2003) asked 152 healthy participants to partake in a stress test in order to assess pain tolerance using the cold pressor technique. Participants were divided into control and experimental groups, either rest or a stress-inducing public speaking task. Both groups were also asked to complete salivary cortisol swabs, enabling the researchers to compare pain tolerance with changes in cortisol (stress) hormone levels. Results from the study were found to run contrary to predictions: participants who were allocated to the stress condition actually reported less pain during their cold pressor task, despite the public speaking task definitively elevating their stress levels. Though cortisol concentrations did increase from pre- to post-test for both conditions, cortisol failed to account for the variance in pain perception between groups. The group who were asked to do public speaking showed no larger increase in their cortisol after the cold pressor task than those who had not done the task. Despite this, induced stress via public speaking did attenuate pain. Cortisol concentrations were therefore not linearly or at all related

to the degree of pain felt.

It seems then that the relationship between cortisol, pain and stress is more complex than first thought. The results from this thesis challenge perceptions surrounding the connectivity between stress/cortisol and pain. The linearity was not as clear as expected and there was minimal impact of the interventions on cortisol concentrations. It is possible that, as stated by al' Absi and Petersen (2003), any reduction in pain perception may not be accounted for by cortisol, but may reflect other hypothalamic-pituitary-adrenal (HPA) axis hormones. al' Absi and Petersen (2003) considered that peptide hormones such as ACTH and  $\beta$ -endorphin can dynamically influence pain perception under acute stress. It is possible therefore that the changes embodied in the questionnaire and qualitative data may have been better modelled in the assessment of alternative hormones and opioids. Further research would clarify this proposal.

An additional difficulty in the analysis of the cortisol data concerns the impact of opiate analgesics and patient diagnosis. Opioids are considered to be inhibitory of HPA axis function (Kudoh et al., 2002). Opioid inhibition of the HPA axis would mean that cortisol concentrations are modulated and stabilised somewhat even in the context of significant stress post-surgery. All patients in this study were administered opiate analgesia, and this may have lessened the magnitude of the cortisol response to changes in pain level. Similarly, patients with rheumatoid arthritis are often treated with corticosteroids and corticosteroids may be a cause of reduced adrenal activity (Heim et al., 2000). The medication taken by rheumatoid arthritis patients was not monitored in this study as it not specifically analgesic, but it may have affected cortisol production in these patients. In summary, the research into cortisol in this study suggests that surgery may be stressor of such magnitude that it is not susceptible to change. Research could pursue the issues surrounding stressor magnitude in the modulation of cortisol responses to an intervention. Testing of other hormones and opioids could also provide more information surrounding the responsivity of the HPA-axis to pain modulation.

#### **8.3.1.5 Nausea and Vomiting**

The final theme from the physiological category was that of nausea and vomiting. Patients related feeling significant levels of nausea and repeated vomiting in the first four days following surgery. Intra-operative analgesia can cause post-operative sickness and anti-emetics were used in this study in order to minimise this side-effect. Future research should monitor rates of nausea in order to ascertain to what extent the analge-

sia used is negatively impacting upon recovery.

## **8.3.2 Psychological Category**

### **8.3.2.1 Mood Disturbance**

The first theme arising within the psychological category surrounds the influence of the surgery on patients' mood states. Immediately following surgery, patients expressed feelings of relief that the procedure had been completed, but this was juxtaposed against struggling with negative mood states as a result of significant pain. When pain was high patients felt emotionally negative and when pain was low, their mood improved. This demonstrated the intimacy of the connection between physiology and psychology. Previous research has shown that pain-related anger and sadness are associated with elevated pain levels and physiological responses (Rainville et al., 2005). In this way the relationship between pain and mood is two directional: pain-related emotions influence pain perception, but pain increases emotional disturbance. This finding validated the results from the Profile of Mood States. Patients displayed highest levels of mood disturbance on Day 1 and their mood disturbance subsequently decreased across the course of the study. The exception to this was the dimension of Anger–Hostility which was at its lowest on Day 1 and then increased with time. It is likely that the low levels of Anger–Hostility on Day 1 reflected the relief that the surgery was complete, as shown by the qualitative results. When the relief waned and post-operative pain increased with the removal of the Patient-controlled Analgesia device, Anger–Hostility therefore increased.

The results surrounding mood suggested that patients set themselves high standards for their recovery. Patients reported feeling frustration if they did not feel well on a particular day or if their pain and function was greater than anticipated. Their frustration was both at their rate of recovery and their daily well-being. Patients were concerned by pain-related loss of concentration and inability to cope. These aspects may also have contributed to the elevated Anger–Hostility levels as time progressed. When patients remained in hospital, they grew increasingly frustrated that their health status was not stable enough to merit their return home. This was often accompanied by worry: patients worried about their well-being and about when they would be able to leave hospital. Thus the patients remaining on Day 5 showed the highest levels of Anger–Hostility. This frustration with their 'performance' on recovery can be related to research into perceptions of self from clinical psychology. Self-concept and a per-



son's degree of 'enmeshment' with their pain have been central tenets in the research of clinical psychologists (for example Morley et al., 2005). Enmeshment is defined as the degree to which sufferers view and experience their self as entrapped and limited by their pain (Morley et al., 2005). Higgins (1997) proposed a theorised division between ideal, actual and ought selves (Gillanders, 2006). The ideal self pertains to the attributes that oneself or another feels that they aspire to—a goal-state. The actual self is the current context of the pain sufferer and the ought self is how they feel they currently should be. It seems logical to presume that if a pain sufferer considers their recovery to be 'behind' and slower than they might hope, then their mood is negatively impacted as a result of their negative pain enmeshment. This can, of course work in reverse, with patients' actual selves as better than their ought or ideal selves, resulting in lower mood disturbance and positive self-perception. This is embodied in the qualitative results which describe patients deliberately viewing their pain positively and noting how far they have come in their recovery. They are maintaining a more positive 'actual' self in relation to their ought and ideal selves.

The deliberate activation of a positive mental state is important. Those patients who deliberately activate positive mentality and goals may be exhibiting 'response shift'. Following Razmjou et al. (2006) response shift is:

A psychological change in one's perception of the quality of life following a change in health status. [It is] a psychological construct whereby an individual changes his or her internal standards, values or conceptualisation of health-related quality of life over the course of time. (Razmjou et al., 2006, pp. 2590-2591)

Razmjou et al. (2006) investigated the impact of response shift on patients undergoing Total Knee Arthroplasty. Though 'response shift' is typically seen in patients who are suffering from long-term terminal conditions (see Wilson, 1999), Razmjou et al felt that it was important to address the issues surrounding whether response shift can impact patients who were not suffering from terminal conditions, but instead had undergone elective surgical interventions. Total knee arthroplasty patients were recruited at their Pre-admissions Clinic and were assessed again at six months post-operatively. Patients were asked to complete the Western Ontario and McMaster Universities Arthritis Index (WOMAC) at pre-admissions (pre-test), and then at their six month assessment. They were completed the WOMAC for 'now' (six-months after surgery; post-test) and to reflect back to their pre-operative status and to complete the WOMAC for their perceived pre-operative pain and disability (their judgement on their condition prior to surgery; then-test). The six month interval was chosen in order to

allow enough time for patients to recover from the acute pain, swelling and functional inhibition from the arthroplasty surgery, and to ensure that patients were unlikely to remember their previously given (pre-operative) WOMAC responses.

It was found that when reflecting back onto their perceived pre-operative condition (then-test), patients judged themselves to be significantly worse than they had considered themselves to be at that pre-operative (pre-test) stage. Domains of pain, physical function and total WOMAC score showed the presence of a response shift. Essentially patients had distanced themselves mentally from their pre-operative condition and had 'shifted' their perception of their pain at that point in order to augment their current perception of excellent post-operative quality of life. Response shift allowed them to offset their pre-operative pain against their post-operative recovery status and to view their recovery in a more positive light. Patients subsequently considered themselves to be significantly worse pre-operatively than was actually true at the time, and therefore they perceived that they had improved much more by the time they were assessed at 6 months post-operatively. This response shift was not dependent on age, gender, amount of recovery time or co-morbid medical conditions. It suggests that patients' internal standards change over time following treatment (Razmjou et al., 2006).

Response shift may also have been demonstrated in the study by Wright et al. (2004), who found that 74% of patients demonstrated at least a great improvement following the knee replacement when they looked at the improvement in quality of life. Also, 74% of patients would undergo surgery again if required. The results of this thesis with the improvements in mood disturbance and in functional ability as days of post-operative recovery progressed, may represent a 'response shift' formed by patients in the course of their recovery. Qualitatively patients asserted their happiness that they felt better and were notably improved from the preceding day, thus they may have been distancing themselves from their previous state in order to reframe their recovery more positively. In non-life threatening conditions, it perhaps seems difficult to comprehend the value of a response shift, but in the case of orthopaedic surgery, patient satisfaction is affected by their pre-conceived expectations of their recovery and outcomes (Ethgen et al., 2004). Thus response shift may function to enable orthopaedic patients to maintain a positive 'actual self' even in conditions of severe pain and slow recovery.

Qualitative results from this study indicated that patients were experiencing both short- and long-term response shift. From pre- to post-test, patients felt that their pain had improved and reported being more positive. This represents short-term response

shift, by which post-test state is perceived of more positively than pre-test. In addition, patients showed daily response shifts, repeatedly stating how much they had improved since the previous day and reiterating how difficult their pain and function had been on earlier days of testing. This is an extremely interesting avenue of research that could provide information regarding how patients cope with pain and functional disability post-operatively and then view their surgery at a later date. Further research is required to investigate the longevity of response-shift and the susceptibility of response-shift to an intervention.

### 8.3.2.2 Engagement and Absorption

Qualitative results demonstrated that patients perceived there to be fluctuations in the efficacy of the interventions. The primary explanation for this was how focussed patients were upon the interventions. When patients felt that they had not been absorbed in the stimulus, they found that the intervention was less successful. Therefore a further primary theme within the psychological category is that of absorption in the intervention: how deeply interested and fully attentionally engaged the person was with the stimulus. Research has suggested that the amount of actual engagement in music mediates the efficacy of that music as a cognitive-coping strategy (Leventhal, 1992). If a person is not effectively engaged by music listening, then they may demonstrate no effect. As Sloboda (2002) states:

The music by itself will not automatically induce the desired mood state, listeners should really try hard to get into the mood, using whatever means they find most effective...within the same experiment, some participants report to be highly affected by the manipulation, whereas others remain unaffected. (Västfjäll, 2002, as cited by Sloboda, 2002, p.383).

Essentially, the potential of music to exert an effect, be it as pain relief or arousal, is dependent on the level of active engagement on the part of the listener. Hearing music does not automatically provoke high levels of engagement and absorption for the person listening. Music is not an 'auditory vitamin pill' or a pharmaceutical property of the sound stimulus (Sloboda, 2002, p.241). Good et al. (1999) demonstrated this empirically: audio-analgesia as a result of sedative music was more effective if the patient was actively able to concentrate on the intervention.

In validation of the importance of absorption, research has shown heterogeneous effects of music listening (see Phumdoung and Good, 2003), with some participants achieving greater analgesic-effects than others. If a listener is not adequately absorbed

in the cognitive-coping strategy, then the results of the intervention may be minimal. By contrast, someone who actively focuses upon and becomes absorbed in the stimulus may find the intervention more effective. The qualitative results of this study indicated that patients showed varying degrees of focus on the music across different days of testing. Some patients found the intervention highly effective on some days and ineffective on others. Patients stated that they found concentration difficult in the early post-operative period and that their absorption levels were variable as a result. The severity of post-operative pain in the first few days of testing will have demanded a large portion of information processing in the CNS. If attention is viewed as a finite resource, and pain as demanding of attention (see page 13), then it is logical that concentration became difficult for participants when the pain was at its most severe on Days 1 and 2 post-surgery. In particular, qualitative data showed that patients struggled with tasks which required additional cognitive processing, such as reading and watching television. However, patients did not complain about struggling to concentrate on the music.

Music is a highly familiar stimulus and as such is readily processed (see Chapters 3 and 4). Information processing is a two-directional trade-off between automatic, unconscious, bottom-up processing and effortful, deliberate, top-down processing (Hammar et al., 2003). The wealth of daily exposure to music for the majority of people, indicates that base-level familiarity with musical stimuli is high. Therefore, musical signals are regularly processed and cognitive pathways are thought to be primed for musical perception (Thaut, 2005). Hearing music is considered to be an automatised associative result of sound processing (Nattiez, 1990). If this is the case, music may be a less cognitively-demanding, more automated activity than the reading or television-watching which patients found more difficult. So if the intervention did not evoke attentional overload (unlike reading and watching TV), then why did differences in absorption levels occur? It is important to realise first that quantitative research confirmed that patients achieved a meaningful level of audio-analgesia across all days of testing. However, qualitative data showed that individuals found some days more successful than others. Absorption is an extremely important because low levels of self-absorption may result in poor compliance with study methodology due to boredom or frustration, which may cause reduced responsivity to treatment (Phumdoung and Good, 2003). The answer undoubtedly invokes the concept of deliberate focus. Phumdoung and Good (2003) suggested that the benefits of music listening may be mediated by the ability of the person to apply them. Where patients are passive or hos-

tile towards the intervention, focus will be low, but where patients are active and able to pay attention to the intervention, focus will increase. Encouraging active absorption in the stimulus or methodology is therefore highly salient to psychological methods of pain control.

Though focussed attention may promote greater audio-analgesia, research into laboratory-induced pain caused by noxious thermal stimuli has found that pain can be reduced by music listening even when levels of absorption are low (Roy et al., 2008). It is this which can explain the quantitative finding of consistent pain reduction in this study, despite variations in absorption rates. Roy et al asked participants to deliberately focus upon the noxious stimuli and away from the music, whilst experiencing noxious stimuli. Despite this deliberate avoidance of focus on the intervention, pain levels were still reduced by music listening (see Roy et al., 2008). In this way music is modulating pain to some extent even if the music is not the active focus of the patient. Processing of music therefore must interact with pain processing, thereby modulating pain intensity. Both auditory and neurological pain systems are connected in several regions of the reticular formation and lower thalamus (McCaffrey and Good, 2000). It has been hypothesised that auditory stimulation may occupy sensory neurons that are similarly utilised by pain signals, thereby limiting the transmission of pain messages (Ortiz, 1997). Further research is required in this area to finitely determine how and where auditory information may modulate pain processing.

If focus or engagement is so important for the response to a psychological intervention, how can it be assessed? It is possible to monitor absorption in an intervention. Eccleston (2001) and Loui et al. (2005) advocated the use of a two-directional approach to monitoring the efficacy of an intervention. Patients were asked either to focus on the intervention for a 'focussed-trial', or to divert their attention to another cognitively-absorbing task such as a serial search or comprehension task (Loui et al., 2005) whilst still exposed to the intervention—an 'attention-diversion' trial. By comparing the results, it was possible to identify the difference between high and low levels of attention to the stimulus. As absorption was not monitored in this thesis it is not possible to draw conclusions beyond the qualitative information provided by participants. Results do indicate, however, that absorption and attention is an area by which an intervention can become maximally or minimally beneficial. Further research could use a two-directional paradigm to assess this issue further.

Panksepp and Bernatzky (2002) recommended the use of associated imagery to recruit deeper affective structures. Cognitive-coping skills have been divided as imagery,

self-statements or attention-diversion techniques. Music is an attention-diversion methodology, but qualitative results indicated that listeners supplemented this by invoking imagery. As found in the studies by Lai (1999) and Sloboda (2002), participants imagined themselves in familiar locations, in positive surroundings, re-enacting personally salient memories and doing tasks which they enjoyed. This spontaneous use of imagery shows that patients often have an existing repertoire of cognitive-coping strategies which they can use when desired and when given ample opportunity. The intervention used in this study was not designed to facilitate additional cognitive-coping strategies, but qualitative results showed that music or quiet relaxation provided space for patients to practise and utilise their repertoire of cognitive-coping strategies—it is possible that patients' pain relief can be attributed to this. If participants found it difficult to achieve an operable level of self-absorption in the stimulus due to pain, then the ability of the intervention to promote cognitive-coping is limited. By invoking imagery, some patients were actively precipitating greater absorption by supplementing the intervention with other coping skills from their repertoire. Not all participants used imagery, however. A considerable number of patients in this study reported remaining mentally 'blank' during the intervention and stated that they were not thinking at all. Thus patients were divided in their strategic use of cognitive-coping strategies, some patients invoked additional methods and others did not. Given the importance of absorption, it would be advantageous to compare music listening with imagery against music listening without imagery in a clinical post-operative pain setting. If a combination approach does help with greater absorption, this would influence findings in this area.

Research has suggested that patients can be coached to develop and to improve upon cognitive-coping strategies. Cognitive-behavioural approaches often depend upon patient training and re-education and this has been consistently successful in pain management settings. It is possible, therefore, that patients could be taught methods by which they could increase their absorption in music—facilitating 'deep listening'. This follows recommendations by McCaffrey and Locsin (2002) who instructed participants to become quiet and still in order to aid immersion in the music listening. In addition, Good et al often suggested that patients 'close their eyes and focus on the music'. In this way patients were being taught ways by which they could elevate their focus and potentially facilitate greater pain relief. Patients in this study were asked to refrain from other activity and to listen to/focus upon their music or quiet intervention. This may constitute some degree of 'coaching' and may have aided the patients in

this study. Yet research into music and ‘therapeutic suggestion’ found no advantage for the combination approach over music alone (Nilsson et al., 2001). Good et al, by contrast, found that the combination of music and jaw relaxation was advantageous for patients, though music heard independently was similarly effective (Good et al., 1999, 2004, 2005). Study surrounding combination approaches is, as yet, equivocal and more research is required. Further study into ‘coaching’ would demonstrate how far instructions could be used to maximise benefits for patients, to promote greater absorption and to limit extraneous or negative influences.

### **8.3.2.3 Learned Association**

Qualitative results showed that patients developed learned associations with the music in the course of their stay in hospital. As outlined on page 44, the use of neutral quasi-preferred music can enable participants to imbue the music with associated physiological and/or psychological meaning and responses. Music can be positively or negatively associated with previous events, symbolic meanings or behaviours and in that sense can dictate or influence subsequent responses to the intervention. Qualitative results indicated that patients learned to associate their intervention with improved mood, distraction from pain, relaxation and an opportunity for personal privacy. The consistent changes in pain scores demonstrate that the intervention did not wane in efficacy, but continued to be beneficial throughout the study. This meant that patients attributed positive outcomes to the stimulus and repeated exposure to the intervention continued to evoke these outcomes, though they were modulated by absorption. Chafin et al. (2004) considered that the benefits of music could rely on a conditioning mechanism: music could be associated with calm and relaxation and would therefore be more likely to induce the psychological and physiological effects with which they are associated. Qualitative results showed that patients perceived consistent benefits in the course of their repeated interventions. The stimulus was therefore effective at invoking these effects, but patients also psychologically contributed to the prolongation of benefits through learned associations and conditioning mechanisms.

Qualitative results showed that learned association and the perceived benefits of the intervention depended to a large extent on the expectations of the patient. Patients who were convinced of the efficacy of the adjunctive treatment were receptive to the intervention. Those who considered ‘actual’ pain relief actioned through pharmacology as essential had neutral or negative perceptions of the research. Expectations governed the effect and evaluation of the intervention. This indicates that there are cultural differ-

ences in the perceived value of music and this extends to culturally-based beliefs in the affective power of music. Just as musical preferences are governed by cultural knowledge and expectation (Good et al., 2000), expectations of success or failure are dictated by the views and confidence of the individual in the intervention. The therapeutic effect of music is enhanced when a person has been prepared to listen (McCaffrey and Locsin, 2002). If the person listening to music is attentive to the stimulus and views it as a catalyst for change, then the expectation for success is positively primed and the outcome is more likely to be successful. Manipulating expectation is not appropriate within the confines of an objective quantitative research study, but for daily inclusion of music in a clinical setting, it is possible that heightening positive expectations would assist in the reception of music as a viable contributor to a multi-modal care regime. McCaffrey and Locsin (2002) suggested that music should be deliberately presented to the listener with the intention of assisting the healing process on physical, psychosocial, emotional and spiritual levels. Essentially this constitutes patient re-education.

The dominant perception of medicine in the United Kingdom remains the Cartesian model: pain as proportional to the degree of tissue damage. Conceptualising pain in this way remains a dominant viewpoint despite the fact that pain theory does not support this theoretical stance and that the biopsychosocial model of pain has long been ensconced as the idealised gold standard for care. Patients are often very reluctant to consider that psychology has any relation to their physical status and may even feel threatened were such a concept suggested. Patients can consider 'psychosomatic' dimensions of pain or illness to be a threat to the validity of their disease and treatment. Such a sentiment may be taken by the patient as synonymous with an implication of some sort of mental illness or accusation of malingering. Re-educating patients about the difference between their biomedical disease model and the reality of the biopsychosocial and neuromatrix theories of pain could enable patients to appreciate the power which they themselves have to contribute to their treatment. This has the potential to improve their post-operative stay and recovery rate and could significantly impact on psychological well-being. The biopsychosocial concept of pain is a simplistic concept that is easily explicable, but has the benefit of improving knowledge of pain and potentially reducing patient anxiety as a result of better pre-operative preparation. Such re-conceptualisation of pain and illness is common in chronic pain clinics, but has, as yet, not been implemented in an acute pain setting.

Flaten et al. (2006) conducted research with healthy volunteers who were exposed to laboratory-induced pain through the submaximum effort tourniquet test (see Flaten



et al., 2006, for further information). Participants were placed in two experimental groups and were given neutral or positive information to alter participant expectations. All subjects were told they were to receive analgesic medication, though in reality this was a placebo drug. The neutral group were told that they would receive analgesia, but were not offered any information about the drug, its efficacy or potency. The experimental group received positive information about the analgesic drug, and its efficacy. Results showed that the experimental group expecting positive benefits from the drug displayed increased pain tolerance, and reported less pain for the first thirty minutes after the application of the noxious stimulus. Positive drug information therefore increased placebo analgesia and pain tolerance, indicating that positive information induces stronger expectancies than neutral information. This could therefore govern the responses of patients to a cognitive-coping intervention. In summary, patients did activate a learned-association system and this precipitated responses to the treatment intervention. Patient evaluations of the efficacy of the treatment was related to their expectation of change. Re-education could contribute to better pain management in an acute pain setting in the way that teaching about pain has been utilised in chronic pain clinics. Further research could manipulate positive with negative expectation of an intervention in order to evaluate the role of association and patient expectation on pain reduction and pain tolerance.

#### **8.3.2.4 Distraction and Relaxation**

Qualitative results showed that patients viewed the intervention as both distracting and relaxing. Just as found by Good et al. (2005), patients viewed distraction and relaxation as intimately connected and co-dependent. Relaxation was activated by distraction. From attentional diversion came concomitant muscular and psychological relaxation. Patients found that devoting their attention to a task external to the pain experience facilitated the release of muscular tension, which was equated with feeling relaxed. This validates the findings of the study by Voss et al. (2004). Limiting affective distress has been associated with increased comfort and relaxation (Stevenson, 1995). Quantitatively, the reduction of affective pain by the intervention on all days of testing confirmed this. Patients reported feeling more positive and less distressed after their intervention, indicating that the intervention did function as a relaxant in this way.

Distraction occurred both as a function of the music and through supplementary cognitive-coping strategies. The music or quiet intervention was perceived of as a method by which patients could separate or distract themselves from their pain. In the

course of their interventional period, some patients also utilised imagery, which supplemented the distraction provided by the intervention itself. As suggested by Chafin et al. (2004); Khalifa et al. (2003), the distraction was two-directional: it both diverted attention from pain and enabled patients to avoid ruminating on their pain. Two-directional distraction is logical as the health impact of an intervention encompasses the time period after the stressor has passed (e.g. post-surgery) and when the person is ruminating about and recovering from the episode. Qualitatively participants noted both that they were distracted from their pain *by* the intervention, and also that they did not think about their pain *during* their intervention. Quantitative results proved that this had a positive effect on post-test pain scores. Thus the ability of the intervention to distract from and prevent negative rumination was highly advantageous for patients. For those participants suffering from self-reported anxiety and depression disorders, the potential of the intervention to enable patients to avoid thinking about their pain is particularly important. Anxiety and depression have been connected with negative perception of pain and pain catastrophising (Granot and Ferber, 2005). Catastrophising is a thought process characterised by an excessive focus on pain sensations, with an exaggeration of threat and the self-perception of not being able to cope with the pain situation (Sullivan et al., 2001). For patients with mental health disorders, minimising catastrophising by preventing negative rumination reduces psychological distress, pain intensity and pain-related disability and promotes greater success in recovery (Pavlin et al., 2005; Turner et al., 2002).

The results of this study indicate that care must be taken when interpreting the results of a music listening intervention as solely distractive. Though distraction does occur, qualitative and quantitative findings indicated that distraction was related to relaxation and that they were perceived of as dynamically interrelated by participants. Roy et al. (2008) questioned the predominant perception that music only distracts from pain. Roy et al state that research has shown that unpleasant emotional stimuli or other cognitive-distraction tasks which are similarly distractive (such as humour or maths as researched by Mitchell et al., 2006) do not reduce pain. It is thought therefore that distraction cannot be the only mechanism by which music listening impacts upon pain perception. The results of this study are interesting in relation to this assertion by Roy et al. As Roy et al found in their research, music did reduce pain, but contrary to their corollary statement, the other task—quiet relaxation in this study—also reduced pain. The time of quiet relaxation, in which patients were not exposed to a specific activity, was still successful at minimising pain (see page 216 for discussion). Thus

this suggestion by Roy et al. (2008) is problematised. It is evident then, that some conflict exists within the literature concerning which cognitive-coping strategies are most effective for pain control, and the way in which they function. The predominant viewpoint is that cognitive-coping strategies are diversionary tactics, but the results of this study showed that both interventions were distractive and relaxing and these concepts were not separated by patients. It is possible that pain may best be reduced not by solely cognitively-demanding distraction tasks, but by methods which allow patients to invoke distraction alongside other concomitant benefits, such as relaxation and a heightened locus of control. Thus interventions which are absorbing, but which are personally salient may be most advantageous.

The emotional valence of the intervention is thought to mediate analgesia to a greater extent than its distractor value (Mitchell et al., 2006). Greater emotional engagement in the distraction task increases the efficacy and absorption of the person in utilising the cognitive-coping method. Emotional reactions to music may activate the PAG, amygdala, prefrontal cortex and the cingulate cortex—those areas of the brain which are thought to be related to pain modulation (Blood and Zatorre, 2001; Roy et al., 2008). Though both interventions in this study were emotionally neutral (quasi-preferred music or quiet relaxation), qualitative results indicated that patients imbued their interventions with personal and emotional relevance, through thoughts, memories or imagery for example. In addition, as outlined in chapter 3, cognitive-coping strategies resonate on many different levels psychologically and sociologically. Emotional engagement with the stimulus was not deliberately manipulated in this thesis, thus further research is undoubtedly required to compare between distraction types in order to clarify what cognitive-coping methodologies are consistently effective. This should prioritise research into strategies which are solely distractive and strategies which can resonate on multiple levels or facilitate the use of more than one cognitive-coping technique at a time. Likewise, comparisons should be drawn between emotionally-resonant and uniquely cognitive methodologies.

#### **8.3.2.5 Locus of Control**

Following McCaffrey and Locsin (2002), the issue of locus of control in treatment is extremely important. In an unfamiliar medical setting, when there is limited opportunity for agency in care, providing patients with an opportunity to assist in their treatment is hugely influential. This can reduce feelings of vulnerability, impotence and learned helplessness. Qualitative results from this study clearly show that the interven-

tions provided valuable opportunities for patients to engage with their own treatment. Providing patients with the opportunity to use an intervention which they have chosen and which they engage with, enabled patients to be active in their own recovery: patients felt that they were participating in changing their pain and improving their mood state. By rating their pain daily, patients were able to track their improvements and monitor reductions in their pain levels. Providing patients with an opportunity for personal privacy was greatly appreciated and patients noted how this facilitated positive response shifts and renewed their ability to cope. In addition, the methodological category noted a theme of 'assisting others'. Just as patients felt that their own locus of control was improved through their involvement in the study, they were additionally glad to support the research if it had the potential to assist other patients in the future. Overall, qualitative data showed that the intervention was positively received. In this way, the results correlated with those of Evans (2002) who noted that cognitive-coping strategies improve patient satisfaction with treatment. The locus of control was therefore elevated through this study and patients felt that this was beneficial to their physiological and psychological well-being and that of future patients.

#### **8.3.2.6 Depression and Anxiety**

Anxiety is conceptualised as subjective feelings of tension, apprehension, nervousness and worry. Depression is characterised by a pervasive low mood, loss of interest in or pleasure in normal activities. That a significant number of patients in this study suffered from self-reported depression and anxiety disorders is in confirmation of research by Lingard and Riddle (2007) who noted that psychological distress affected approximately one quarter of patients scheduled for arthroplasty surgery. The Kinemax Outcomes studies also noted that poor pre-surgical mental health predicted recovery post-operatively. In confirmation of the findings of these studies, post-operative quantitative results did display differences between healthy and depressed/anxious patients in pain, speed and magnitude of recovery. Depressed and anxious patients in this study showed poorer pain and function scores, but still exhibited significant improvements across the period of their post-operative recovery. Lingard and Riddle (2007) stated that Arthroplasty surgery represented a significant boost to patients and it facilitated vastly improved mental health. The improvements in post-operative well-being for people of low mental health status in this study validated this supposition. However, Lingard et al also found that mental health problems predicted persistently higher levels of pain and functional inhibition even at 6 months, 1 and 2 years post-operatively.

Though the scope of this research did not extend beyond discharge, further study could follow patients longitudinally to consolidate information about the long-term effects of mental health on recovery. This thesis was not designed specifically as research into depression or anxiety, therefore further research needs to be conducted on the responses of patients with mental health problems following surgery and in response to a music-listening intervention. To compare between patients with different mental health status undergoing different types of surgery would likely contribute to a greater awareness of the role of audio-analgesia in patients with mental health disturbances.

### **8.3.3 Musicological Category**

Having evaluated the physiological and psychological results of this study, it is important to discuss findings which pertain to intra-musical elements. The aim of this research was to investigate whether manipulating harmonic and rhythmicity influenced the efficacy of an audio-analgesia intervention.

#### **8.3.3.1 Harmonicity and Rhythmicity**

Contrary to all expectations, the majority of results in this study showed no difference between groups: ++, +-, -+, -- or control. There are a number of possible explanations for this. The first concerns the appropriateness of the control group. For the purposes of this study, it was decided to use noise-reducing headphones for the control group. This was a rational choice based upon a desire to maintain blinding for participants. If patients were recruited to a 'music' research study and were not then supplied with music, their grouping would have been immediately apparent. Thus patients were recruited to a 'relaxation study' which included quiet relaxation or music listening. In this way it was possible to identify the extent of the placebo effect with the 'quiet' participants and to ensure that control group participants were not demoralised or disinclined to continue with the study as a result of their group allocation. The alternative control group would have been a standard care control group who received no intervention, but were assessed before and after 15 minutes of normal daily activity. This would have been a possible choice, but was problematised for the reasons above, and in the Royal Infirmary of Edinburgh because of the location of multiple patients within one nursing bay. It was not possible to ensure that patients recruited to the music section of the study would not be placed in beds in the vicinity of patients allocated to the quiet relaxation group. Therefore it was important that all patients were informed

similarly that they were in a 'relaxation study'.

As a consequence of the use of noise-reducing headphones for the control group, the music intervention was therefore compared with a baseline treatment as opposed to a 'no treatment' group. Research by Lee et al. (2005b) also used headphones for their control group. Similar to the results of this study, they found that the control group reported that the headphones eliminated some of the anxiety that was an inevitable as a result of the continuous background noise occurring in the ICU. The orthopaedic setting of this thesis had a considerable amount of background noise—beeping, medical activity, televisions, and visitors. The control group reported that the headphones did significantly reduce external noise. As a result they noted feeling greater relaxation and less pain. The headphones therefore were an active intervention for all participants, including the control group. The reduced noise and the opportunity to have a period of privacy in the day was advantageous for all participants, regardless of grouping. It is likely that the choice to use noise-reducing headphones with the control group minimised the distinction between patients as all benefited from the intervention in some way. Future research should therefore strive to devise a blinded methodology that compares standard care with musical interventions. This could offer greater insight into the role of distraction for pain control in a post-operative clinical context.

A second explanation for the similarity between the responses of all participants concerns the choice of harmonicity and rhythmicity as categorisation constructs. The results of the study show that manipulating high and low harmonicity made minimal or no difference to pain, functional ability, mood or physiological markers. When recognition of harmonicity and rhythmicity are innate abilities, which are identifiable in all normal music listeners and can be supplemented by acculturated knowledge (see Chapter 4), this is an extremely interesting finding. Music which had low harmonicity and rhythmicity was essentially as effective as music with high levels of harmonicity and rhythmicity. None of the four possible combinations of high and low harmonicity or rhythmicity had any advantage over the others. Even the ++ music which was potentially more familiar to participants as Western music, showed no consistent advantage over no music or the more culturally-unfamiliar -- music. To refer to the body of research by Good et al (see Good, 1996; Good et al., 1999, 2004, 2005; Good, 2008; McCaffrey and Good, 2000; Phumdoung and Good, 2003; Voss et al., 2004), this consequently brings into question the oft-used dyad between sedative music and excitative music. If ++ or -+ music is excitative and +- or -- music sedative, then there would likely be no difference between groups for sedative or excitative music.

Further research is required to explicitly test this hypothesis.

The question remains: why was there no difference between groups? It is plausible that high and low harmonic and rhythmicity were not clearly delineated enough. Given the difficulty of finding music which is at the extremes of the scale continuum, this is a possible explanation. However, untrained listeners were easily able to differentiate between high and low harmonic and rhythmicity in the chosen extracts (see page 98). That the chosen extracts did not depict harmonic and rhythmicity clearly enough therefore seems unlikely. Ultimately the only conclusion that can be drawn is that the role of music in pain research is not dependent upon compositional constructs. This suggestion validates the findings of the systematic review of music medicine literature published by Nilsson (2008). In evaluating all music medicine literature to date, Nilsson found no effect of musical extract or genre on the efficacy of an audio-analgesia invention. Given the wide-variety of music that has been used in medical research, many compositional constructs will have been depicted, but with no significant differentiation in the level of audio-analgesia induced as a function of the music used. The results of this study indicate that music can reduce pain as found in approximately 50% of the studies reviewed by Nilsson, but there was no advantage of music over no music.

If harmonic and rhythmicity do not dictate the efficacy of music listening, is it then appropriate to use a generic music versus no music experimental design in future research? Can the use of a singular 'music group' be justified? The lack of differentiation in efficacy by group suggests that contrary to what was expected, this may be a rational methodology. Provided that the choice to use music as the intervention is appropriate to the patient population and the music is selected in light of the non-preferred/quasi-preferred/preferred divide, there seems little reason to avoid such music-no music study designs in the future. That is not to say, however, that there is no more work to be undertaken in the field of within-music factors. Beyond compositional constructs, it would be advantageous to investigate timbre, instrumentation, tempo, and volume, for example. This research must be undertaken if the role of music as a cognitive-coping strategy is to be fully understood. Further research is needed, then, to look beyond harmonic and rhythmicity at other intra-musical factors which may impact upon pain management. However, until within-music differences have been found, the original methodology is appropriate following the results of this study.

It must be remembered nevertheless, that the lack of difference between music and no music is a similarly important finding. Where Mitchell et al. (2006) showed an ad-

vantage of preferred music over humour and arithmetic for improving pain tolerance, this study found that quiet relaxation was just as effective as music listening. Though qualitative evidence suggests that the music intervention groups enjoyed their research sessions to a greater degree than the quiet relaxation group, both were equally advantageous for pain reduction. Patients used both interactions to distract, to relax and to facilitate imagery and the revisiting of personal memories. The intervention improved patients' locus of control and enabled them to become absorbed in an activity that was beyond their pain experience and was highly engaging. The intervention promoted positivity and facilitated response-shift, allowing patients to perceive their post-test or post-operative state in a better light than before the intervention. It is perhaps, therefore, the way in which the intervention was able to resonate on multiple personal, psychological and pain-related levels that improved pain management for patients. Future research must therefore compare and contrast between other cognitive-coping strategies in addition to music which have the potential to resonate multi-modally.

### 8.3.3.2 Preference

The results of this research validated the appropriateness of using quasi-preferred music for this study. The aged sample of this population do not constitute the 'ipod generation' and they have not grown up with the personal access to music that is currently available. Many patients referred to LPs and tapes that they listened to at home, and had less access to or owned fewer CDs. A significant number of patients also reported that they predominantly relied on the radio for music, or rarely listened to any music at all. Consequently, to ask participants to choose their own music as required by 'preferred' music may have reduced the sample to only those participants who had a significant interest in music, and who had CDs available at home. The sample would then have been limited in its representativeness of the entire Total Knee Arthroplasty population in Edinburgh. The patient population for this study was significantly older than those involved in the research into preferred music and pain (see MacDonald et al., 2003; Mitchell et al., 2006). Whilst preferred music might be advantageous for younger patients or healthy University-age participants, in the context of the older patients involved in this study, using quasi-preferred music was an appropriate decision.

In addition to issues surrounding access to preferred music, patients asserted the importance of receiving guidance about what music to listen to. Participants were concerned that if they were to choose their own music, they might choose the 'wrong' music. Even within the quasi-preferred selection options, a number of patients felt that



they were not given enough guidance about ‘what music’ they should have chosen for maximal benefit. Patients were particularly worried that they might choose inappropriately or choose something that would make their pain worse. Essentially, they were anxious that the choice of music they made at their Pre-admissions Clinic before they were experiencing post-operative pain, would not be an appropriate choice of music post-surgery. Using quasi-preferred music allowed patients an element of choice, but gave them suitable guidance, thus reducing the fear surrounding inappropriate choices. Therefore, quasi-preferred music reduced patient concerns in the area of selection appropriateness. It should be noted that this did not account for all participants: some (younger) participants did mention that they would like to choose their own music, but these patients were in the minority. Quasi-preferred music was, therefore, appropriate for use in this clinical study.

Within quasi-preferred music, Good et al. (2000) asserted the importance of including a culturally-relevant musical choice. In this thesis, Scottish harp music was added to the ++ category to adhere to this guideline. No patients chose the culturally-relevant music. This indicated that music from a home culture was not important to the Scottish sample in this research. Though the Scottish are renowned for national pride, they did not prioritise music from their home culture over other musics. In the opposite direction, however, participants did not choose the Shakuhachi Japanese flute music which was included in the -- category. This suggested that though patients did not prioritise Scottish music over other options, they did avoid the music from an unfamiliar culture. Instead the -- participants predominantly chose the selection of tracks from ‘Into Silence’ played on the saxophone by Tommy Smith. This extract represented a more familiar musical medium for the participants, with the saxophone instrumentation and jazz-like sound. In this way, cultural relevance was not important, but broad cultural familiarity with the music was preferred. Further research could look in more depth at the role of cultural preferences and prejudices for a British population.

### **8.3.3.3 Familiarity and Complexity**

Lastly within the musicological category, qualitative results displayed the theme of familiarity versus complexity. To review, quantitative results showed that Day 3 represented the greatest leap in pain attenuation, with post-operative days 1 and 2 not significantly different from each other. In addition, qualitative results confirmed that patients felt that they knew the music better with repeated playings. For some participants hearing the same music again helped increase the benefits of the intervention,

with each day of listening better received than the day before. Others described reaching a peak on a certain day of testing, after which point their liking of and benefits from the music declined. This difference in results of pain attenuation and enjoyment may be related to the inverted-U function described by Berlyne (1971). On the first day of music listening the music was essentially unfamiliar, suggesting that the complexity of the music on first hearing would be high and arousal therefore low. With repeated playings, reaching optimum capacity by Day 3, familiarity with the music increased, as validated by qualitative comments regarding increasing knowledge of the music and greater liking for the music as the study progressed. With unfamiliar music and concurrent low arousal levels, it is likely that on the first few days the degree of absorption in the distraction may have been low. With increased playings, the liking for the music increased, the emotional identification with the music grew and the pain reduction was therefore greater.

Berlyne (1971) advocated the concept of an inverted-U relationship between liking for musical stimuli and their arousal potential. The more moderate the arousal potential, the more the music is liked. When arousal is minimal or maximal, liking for the music declines. Unfamiliar music may be perceived as overly complex and thus the arousal potential and liking for a piece of music is dependent on familiarity and complexity. The more familiar a piece of music is, the greater is its arousal potential and liking for the music is high. When a piece is new and unfamiliar or over-played and too familiar, liking for the music and arousal are diminished (see Figures 8.1 and 8.2). To some degree this can explicate the differentiation between cortisol responses to music. This familiarity/complexity/arousal circumplex model was validated in music psychology research by Hargreaves and North (1997). The emotions that participants relay when listening to music are predictable by the extent to which they like and are aroused by the musical stimulus (Ritossa and Rickard, 2004). Liking and arousal are interdependent and linked in their relationship with musical perception and emotion. The relationship is not monotonic, with the most familiar pieces of music loved the most (North and Hargreaves, 1997), but is a dynamic trade-off between personal perception of a particular musical piece which is or is not familiar to the listener. A highly familiar piece can be disliked due to 'over-playing', in which case it is liked less and its arousal potential is diminished. Whilst noting that the inverted-U model is not without its critics (see Martindale et al., 1990), it provides a helpful model for the conceptualisation of dynamic changes to preference and taste (Rawlings and Leow, 2008).

The interaction between pain interference and day of testing indicates that the +

+, + – and – + groups showed this inverted-U patterning. By contrast, the – – groups and control group declined in their degree of pain attenuation across the course of the study. Though this effect represented an interaction and a trend rather than a robustly significant finding, it can be rationally explained through the concepts of familiarity and complexity. ++, + – and – + music represents music which is most familiar in its compositional construction for western listeners. Those three groups have one or more compositional elements which have high harmonicity or rhythmicity. In this way they are applicable to previous knowledge of western music. Explicit memory and subsequent liking for music is most successful when, at the first listening, participants invoke their prior knowledge of the music (Sloboda, 2002). – – music is more unfamiliar to western listeners, with low levels of harmonicity and rhythmicity which mean it is potentially more difficult to parse and learn. The control group were exposed to quiet on a daily basis and this may have invoked boredom effects: where patients appreciated the quiet on the first day they may have found this less effective as time progressed. It is evident, therefore, that familiarity and complexity responses to the intervention did dictate some of the results of this study. It would be possible for future research to assess the familiarity/complexity trade-off in more detail. Participants could be asked to rate their liking for the music on a daily basis and to rate how familiar they feel they were with the stimulus. This would allow experimenters to correlate the relationship between the two constructs.

## **8.4 Limitations**

### **8.4.1 Placebo Effect**

Within medical research, the outcome of a research study is always situated within a social and environmental context. This psychosocial context may influence the experience of the intervention by the patient, positively or negatively enhancing the outcome. The placebo effect is a stable and documented psychobiological phenomenon, whereby “the placebo response is the reduction in a symptom as a result of factors relating to a subject’s/patient’s perception of the therapeutic intervention” (Vase et al., 2002, p.451). Placebo analgesia is thought to be influenced by verbal suggestions,

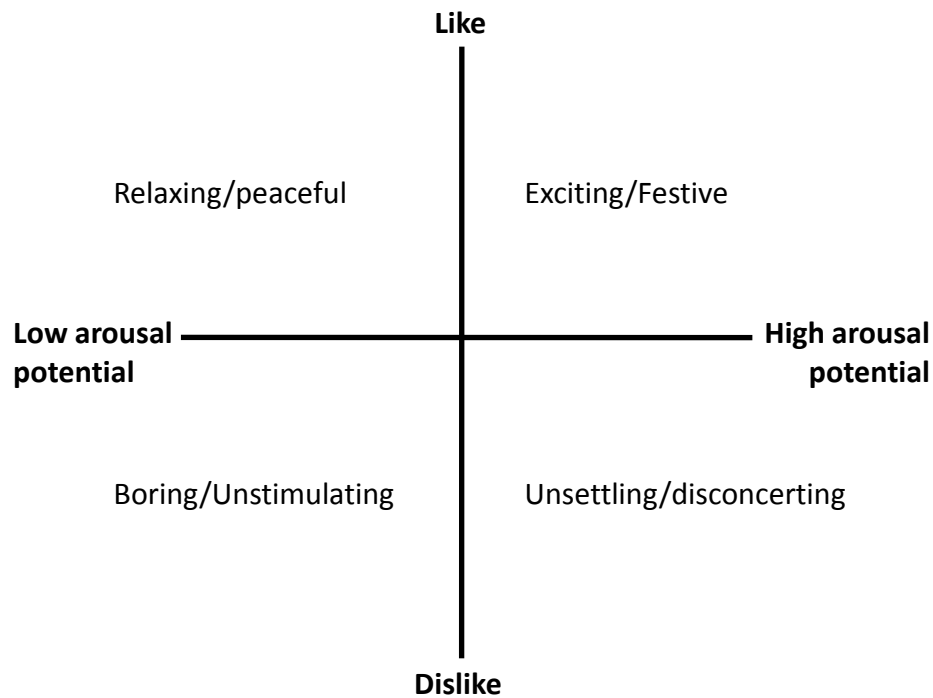


Figure 8.1: The Circumplex Model: Liking, arousal potential and the emotions expressed by music (from Hargreaves and North, 1997)

previous experience, expectancy, memory and desire for health improvement. It may be active through conditioning mechanisms or through generic effects such as anxiety reduction or heightened opioid production (Price et al., 2008). A placebo effect is generally considered to be evident in clinical research if there is no differentiation between the control and experimental groups (Vase et al., 2002). Although the clinical placebo concept is complicated in this research by issues surrounding the choice of control group (as outlined above), it is possible that the uniformity of results may be explicated as placebo analgesia. Just as patients may learn associations with music for positive gain, they may also be conditioned to experience placebo analgesia. Classical conditioning is considered to be associative learning, or the pairing of a neutral stimulus with an expected effect such as potential pain reduction, leads to a behavioural response: experiencing actual pain relief.

A placebo response may be primed by verbal suggestion (Price et al., 2008), for example “listening to this music will reduce your pain”. Care was taken to minimise this risk by terming the research a ‘relaxation and post-operative pain research study’ and by avoiding asking any leading questions. It is possible, however, that participants may

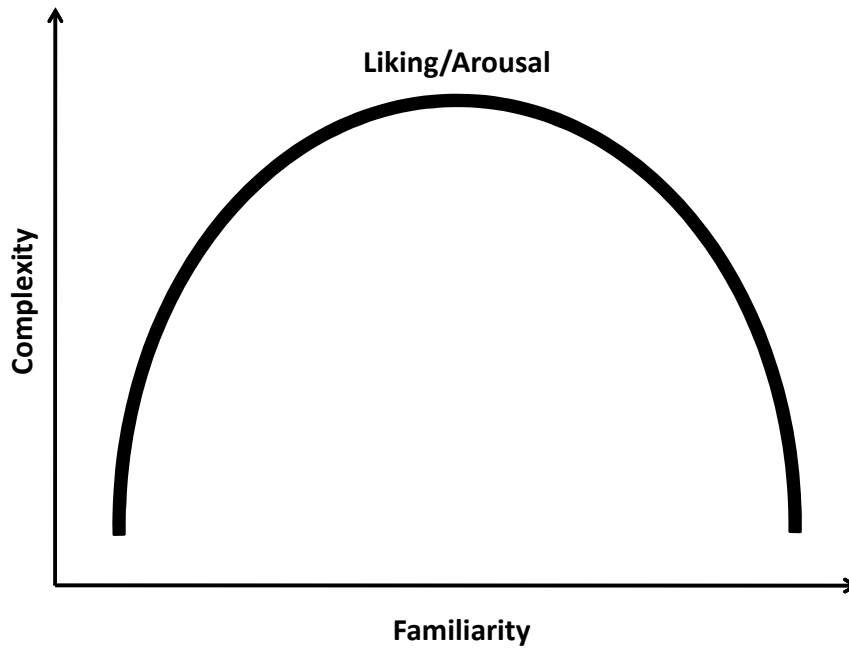


Figure 8.2: Inverted-U function of arousal levels and liking for music in response to dynamic changes in the familiarity and complexity of musical perception (based on concepts outlined by Berlyne, 1971)

have inferred the hypotheses of the study by the questionnaires that were administered. Future research could use a prescriptive verbal script to avoid any differentiation in the way in which patients were treated. Overall, the finding that there was no difference between groups indicates that placebo analgesia was not heightened for the experimental groups in which a positive response was hypothesised. Also, all research (where possible) was carried out by the same researcher, therefore all patients were treated as uniformly as possible and the intervention was administered in the same manner.

Previous experience is also thought to increase the magnitude of a placebo response. Previous positive or negative experience can prime the outcome and response to treatment. Neutral music was used in this study to reduce the likelihood of previous experience and a conditioned response. The existence of this factor in placebo analgesia supports the use of quasi-preferred, neutral music in clinical research. In this way, participants could develop learned associations solely in the context of the experimental research, rather than through prior experience in a previous setting. The placebo response is also thought to be governed by desire or expectancy, meaning “the experienced likelihood of an outcome or an expected effect” (Price et al., 2008, p.571). In

reference to music, expectancy is governed two-dimensionally: through preference and through engagement. The priming effect of preference was diminished in this study by using novel music, and by randomly allocating participants to musical groups rather than to the group listening to their favourite genre. However, as addressed in section 8.3.2.2, engagement with the intervention will always present a challenge in music psychology research. Where patients are passive or hostile towards the intervention, the effects will be different from those participants who are positive and receptive. Wise et al. (2002) stated that a participant's perception of a placebo agent is central to alterations in the magnitude of placebo analgesia. Although expectancy may heighten a placebo response, expectancy (where it is not verbally primed) is an innate human trait and is dependent on personality and patient disposition and cannot be controlled in an experimental setting. Efforts were made to minimise bias in this research study through controlling musical extracts chosen and by blind randomisation of participants.

Lunde (1987) stated that a further challenge to interpreting clinical data is the issue of desire for change. In the context of pain management, such patients strongly desire a reduction in their pain levels. Consequently they may therefore have a heightened perception of psychobiological cues which indicate improvements in their physical health status. This is defined as a somatic focus (Price et al., 2008). Undertaking research with a sizeable patient population reduces the likelihood of patients with strong desires for pain modulation positively skewing results. As data was normally distributed in this research study, this does not pose a significant concern.

Overall, the phenomenon of placebo analgesia is a robust and validated concept and it may play a small role in the results of this study, as would be expected in any clinical research. However, measures were taken to minimise the impact of placebo and it seems unlikely therefore that the placebo effect can solely explicate the main finding of this research: that harmonicity and rhythmicity did not differentially impact upon post-operative pain.

#### **8.4.2 Sample Size**

A sample size calculation in this study estimated that a sample of 34 per group would be appropriate in order to obtain enough power to draw strong conclusions. However, it was not possible to attain this sample size. The experimental data collection in this study was carried out on the hospital wards over a two year period, seven days a week, by a single experimenter (where possible), therefore the practical demands were

extremely high.. Continuing with the research beyond this period was not a viable option. Due to the restrictions on time available with patients and ultimately on the number of patients who could undergo surgery during this time, the optimum sample size was not matched. It is possible therefore that the results shown in this study are at a greater risk of Type I or Type II error. It is also possible that a larger sample size would have shown clearer differentiation between experimental and control groups. Efforts were made to minimise the effects of a small sample size through using standardised questionnaires and procedures and by using a longitudinal study in which subjects could, to some degree, act as their own controls. The sample size of this study is acknowledged and future research could aim to replicate or extend this research using a larger sample size.

### **8.4.3 Extract Choices**

The extracts that were chosen for this study were dependent on the guidelines outlined on page 98. The resulting groups were slightly different in size, meaning that the participants in the ++ group had the most extracts to choose from (6 options) and the -- group had the least (4 options). This discrepancy was as a result of the removal of some extracts following low scores on the pilot study and the addition of culturally-relevant Scottish music. As participants used one (chosen) extract throughout the study, and were not provided with the alternative choices, this slight difference between the number of choices available to participants will not have biased the results.

One extract in the +- category (Debussy) did not quite attain the desired 12–15 minutes, and was approximately 9 minutes in length. This was included due to the exclusion of other extracts that were less indicative of the high harmonicity and low rhythmicity required of the category. As no participant selected this track, the discrepancy in track length did not affect the results. In addition, the systematic review by Nilsson (2008) found no difference in the efficacy of the music listening intervention according to time spent listening. Long interventions performed similarly to shorter interventions, thus the track length did not impact upon the results of this study.

### **8.4.4 Patient Location**

Qualitatively, patients reported (dis)satisfaction with their location—either in a four-bed bay or individual room. Patients in four-bed bays felt that their sleep was interrupted to a greater extent than those in single rooms. In addition, moving wards and

bays caused some patients additional distress. Due to the rapid turn-over of patients and the difficulties of balancing incoming and outgoing patients on a busy ward, it was not possible to dictate that patients remain in their original settings throughout the research. Future research could monitor bed location and analyse whether allocation to single or multiple bed-bays differentiate between patients' pain or receptivity to the intervention.

The interventions in this study were undertaken whilst in bed or in the chair beside the patient's bed, with the curtains pulled around the patient to section them off from the room. As a self-administered intervention, it was impossible to control for adherence to the experimental protocol. It is conceivable that patients engaged in activities other than the intervention whilst behind their curtain (e.g. knee exercises or watching TV). This is not expected to have significantly altered the results however, as patients were requested to refrain from supplementary activities and when asked, patients confirmed that they adhered with this request.

The busy ward location meant that on occasion patients were disturbed during their intervention. This was predominantly due to a nurse putting a dinner tray into the patients' cubicles. Patients were not spoken to or the intervention halted in any way at these times. It may, however, have impacted upon the patients' absorption in the stimulus. Where possible, all interruptions were stopped before the participants were disturbed, therefore the few occasions when interruptions did occur are unlikely to have significantly biased the results.

#### **8.4.5 Technology**

Qualitative responses referred to difficulties with the technology as a thematic construct. The predominantly older patient population had minimal experience with using personal music systems and therefore some found the CD-player difficult to manage. Though participants were not required to operate the player at any point and volume was set in conference with the patient at the outset of the study, some patients wished to alter the volume or to pause the music. Future research could use MP3 players with volume-balanced music, rather than CD players in order to minimise the need for patients to adjust any settings.

Qualitative responses also noted that for the control group in particular, there was some element of breakthrough sound with the noise-reducing headphones. Though efforts were made to reduce noise in the patients' bay during the experimental in-



vestigation, with the arrival of visitors and nursing requirements, this was sometimes difficult. Future research could ask patients to rate the level of breakthrough noise in order to monitor this potentially confounding variable.

#### **8.4.6 Cortisol**

Cortisol, as a dynamic hormone, is susceptible to a wide variety of potentially confounding factors. In particular, age can cause differentiation in cortisol production, as endocrine responsivity slows and endogenous cortisol levels increase with advancing years (Van Cauter et al., 1996). With age, cumulative exposure to glucocorticoids causes hippocampal defects, resulting in an impairment of the ability to terminate glucocorticoid secretion at the end of stress and, therefore, in increased exposure to glucocorticoids which, in turn, further decreases the ability of the hypothalamo-pituitary-adrenal axis to recover from a challenge (Van Cauter et al., 1996). As all participants in this study were of retirement age and therefore reflect a narrow age band, this effect was minimised, but may still have influenced on individual's production of cortisol.

Additionally, cortisol concentration can be related to gender, as pre-menopausal women have slightly lower mean levels of cortisol than men. Female participants were not asked whether they had been through the menopause and this may have influenced cortisol levels for some participants. The age range of participants, suggests, however, that the menopause would most likely have been completed for the majority of female participants. As gender distribution was controlled in the course of randomisation for group allocation, efforts were made to ensure that this did not impact differentially between groups in this study. Ethnicity can also dictate cortisol production (Al-Dujaili, 2008) but as all participants in this study were white Caucasians, this was not a confounding variable of concern.

#### **8.4.7 Sleep**

Qualitatively, patients reported falling asleep during their intervention. Quantitatively, sleep during the intervention was consistently shown for all groups and across all days of testing. Though it would not be ethically viable to require patients to remain awake or to interrupt patients to prevent them falling asleep, it is still possible that sleeping during the intervention may have facilitated greater relaxation and analgesia. In the opposite direction, it is possible that sleep may have limited the power of the music listening intervention as participants did not hear the music. Additionally, sleep has a

significant impact upon cortisol production in relation to the diurnal cycle (Al-Dujaili, 2008), therefore it is possible that by sleeping during the study, participants' hormones did not respond normatively in response to the intervention. Future research could request that patients remain awake, or include sleep assessments in the battery of clinical measures used.

#### **8.4.8 Pharmacology**

It must be noted that a considerable proportion of the depressed patients in this study were taking anti-depressant medication. Kudoh et al. (2002) stated that anti-depressants may be problematic as they change the levels of endogenous opiates and can also have some anti-nociceptive actions. Anti-depressants are often prescribed in low dose for patients with chronic long-term pain problems, thus are widespread in a clinical context. The anti-nociceptive effect of anti-depressants makes it significantly more complicated to identify the role of depression in pain. The magnitude of differences between depressed and non-depressed patients in this study could therefore have been larger, with depressed patients experiencing a greater degree of pain reduction as a result of their anti-depressants. The anti-nociceptive effect of anti-depressants therefore serves to minimise change rather than maximise benefits, thus the differences between depressed and non-depressed patients that registered in this study are most likely conservative estimates of pain reduction. The results will not, therefore, be positively skewed. Future research must continue to take care when working with patients with pharmacologically-managed depression and interpreting their pain scores.

#### **8.4.9 Assessment Completion**

Qualitative themes within the methodology category noted patient concerns over questionnaires and saliva sampling. Some patients felt that there were too many questionnaires or that they were overly complex. The questionnaires used in this study were all well-validated research assessment measures and were recommended by the IMM-PACT task force. The questionnaires had been trialled in research with multiple patient populations and had been found to be effective monitors of pain, functional ability and mood. The measures used were therefore justifiable choices and the quantitative results demonstrated that they effectively discriminated between patients and between days of testing.

Reviews of pain literature have suggested that ratings scales/self-report measures

may be susceptible to demand effects (Westermann1996) and bias. Essentially this means that patients feel required to complete the questionnaire and therefore perform 'on demand'. The inclusion of behavioural and physiological measures minimises the threat of this to research outcomes as PROs can be validated by CROs. In this study, however, CROs showed no change but PROs showed significant improvements across the course of the study and from pre- to post-test. Given the conflict between measures, it is possible therefore that there may have been some element of bias in the PROs. However, as outlined, the measures used in this study were well-validated and have been recommended for use with clinical research. The discrepancy between psychological and physiological results is therefore more likely to be representative of the ability of the intervention to promote improved psychological well-being, but not to improve vital signs or HPA-axis function. Larsen and Sinnett (1991) state that self-report measures are more valid indicators of mood states as there are especially close links between mood-related thoughts and verbally expressed feelings. Similarly, (Dworkin et al., 2005) asserted the importance of subjective pain ratings and PROs for pain assessment. As pain is a highly individual experience and the only person who can accurately describe pain is the person experiencing the pain. It is therefore considered that despite the potential for bias, every possible effort was made to minimise this. The use of PROs is therefore appropriate in the context of this study.

In reference to the saliva sampling, a number of participants were unable to provide samples as a result of nausea, dry mouth or refusal. The cortisol analysis in this thesis therefore represents a smaller population of patients. A side-effect of opiate medication and anti-depressants can be 'dry mouth' and it is possible that this is why a number of patients struggled to produce enough saliva to complete a sample. However, the majority of participants were successful. Further research with larger sample sizes would clarify whether the results displayed in this study are generalisable to the post-operative arthroplasty population as a whole.

## **8.5 Future Research**

A number of suggestions for future research have been provided in the course of this discussion. Additional suggestions are given in this section. Firstly, it would be advantageous to conduct further research into arousal and valence of cognitive-coping strategies used for pain management. This research could extend beyond music and include imagery and other attention-diversion strategies, which were monitored for the

degree of arousal which they initiated and the enjoyment/usefulness of the method as evaluated by the patient. Following Roy et al. (2008), arousal and valence play a significant part in promoting different degrees of pain relief. Pleasant music reduced pain in comparison to unpleasant music or silence, and that was a function of the extent of the positive valence. So music which was more positively valenced produced a greater pain relieving effect, and participants who were less stimulated on the arousal scale also reported less pain. It is important therefore to research pleasant-relaxing and pleasant-stimulating responses to music when experiencing pain.

Research has shown differentiation in the pain tolerance and pain responses of males and females. Kenntner-Mabiala et al. (2007) showed that musically induced arousal affects pain perception in females but not in males. Flaten et al. (2006) found that, total pain reports were decreased only in male volunteers. Similarly, males displayed significantly decreased levels of cortisol compared to females. Mitchell et al. (2006) found that males tolerated the pain induced by a cold pressor task significantly longer than females, but there was no gender difference in pain intensity. Further research is therefore required into pain and gender effects.

The gender of the experimenter relative to the gender of the volunteer has also been found to affect pain ratings (Flaten et al., 2006). Male volunteers reporting pain to female experimenters report lower levels of pain than if they were assessed by male experimenters. Pain reporting by females is ameliorated when females are reporting to male experimenters, though this gender bias is less significant than in males (Flaten et al., 2006). As the researcher in this study was female, research in this area could also be a revealing avenue of exploration.

## 8.6 Conclusion

Pain management should encompass three areas in the concept of standard care: multimodal therapy, attentive care and patient education. All are needed in order to improve patient outcomes for acute pain. Having thoroughly evaluated the impact of music on post-operative pain, it seems that there is justification for the inclusion of music in a pain management programme. The fact that music did not show any advantage over the alternative control intervention of quiet relaxation consolidates the necessity of a 'kit' of adjunctive strategies when working with pain. This research into post-operative pain following total knee arthroplasty has shown that acute pain can be modulated by cognitive-coping strategies. The induced levels of analgesia can attain a level at which

the pain relief is clinically meaningful for patients. Adjunctive non-pharmacological therapies combined with analgesic medication reduce pain and improve the pain experience more effectively than medication alone.

Though music showed comparable reductions in pain intensity to no music, the music-listening was greatly enjoyed by participants. It is likely that 'quiet' interventions would show steady decline in efficacy over a prolonged period of time, whereas music represents a wealth of possible genres, compositions and styles. Thus music is a method which has potentially more consistent effects. Further longitudinal research would clarify this. The current prevailing treatment modality for post-operative and intra-operative analgesia is multi-modal analgesic regimens (a combination approach of different fast, slow and somatically-active analgesic medications). Music listening could also be a valuable contributor to multi-modal analgesia (Nilsson et al., 2003). For osteoarthritis sufferers, there is significant potential for such an intervention to be added to their care pathway as part of a multi-modal programme. This could potentially traverse the boundaries between clinical and community care.

In light of the ease of use, universal availability, widespread enjoyment of and limited financial outlay required by music, its potential utility is evident. In the search for additions to pharmacological interventions and in the effort to maintain a biopsychosocial standard of care, the role of music as a mediator in pain relief is highly applicable. Thus the resonance of music in musicological, medical and psychological domains could be both innovative and inspirational.

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# **Appendix A**

## **Research Assessment Measure**

**Relaxation and Post-operative Pain Study: Pre-admissions Clinic Questionnaire****1. Personal Information**

- Full Name
- Patient No.
- Gender: Male/Female
- Age
- Occupation
- Retired (Y/N)
- GP Name
- GP Practice
- GP Contact Details

**2. Medical and Pain History**

- Where do you feel pain?
- Where do you feel pain most often?
- How long have you had your knee condition?
- What triggered your knee condition?
- Have you had a knee replacement operation before? (Y/N)  
If yes, which knee?
- Which knee will be operated on this time?
- Do you find that your knee problems interfere with your life? (Y/N)  
If yes, in what way?
- Do you suffer from an anxiety or depression medical condition? (Y/N)  
If yes, how does this affect you?
- Do you currently take any form of medication? (Y/N)  
If yes, what medication?  
Is this medication to control pain?  
How often do you take this medication?
- Are you currently undergoing any form of complementary therapy? (Y/N)  
If yes, what type of therapy?  
How often do you use this treatment?
- Do you suffer from any form of hearing loss? (Y/N)  
If yes, how does this affect your hearing?  
If yes, do you currently wear a hearing device? (Y/N)

**3. Relaxation: All Participants**

- How do you relax in your free time?
- Where do you find it easiest to relax?
- Do you prefer to be on your own to relax? (Y/N)
- Have you ever used relaxation techniques? (Y/N)  
If yes, what techniques have you used?
- Do you enjoy the quiet? (Y/N)  
If yes, when?
- Is your sleep easily disturbed? (Y/N)  
If yes, by what?
- Do you find yourself easily distracted from tasks? (Y/N)  
If yes, what distracts you?

Figure A.1: Pre-admissions Clinic Questionnaire

**2. Musical Experience: Experimental Participants Only**

- Do you play a musical instrument? (Y/N)  
If yes, what instrument(s)?  
How long have you been playing?  
Do you still play your musical instrument? (Y/N)
- Have you ever had formal instrumental music lessons? (Y/N)  
If yes, on what instrument(s)?  
For how long did you undertake formal instrumental music lessons?

**3. Musical Preferences**

- What types of music do you like?  
Please give an example
- What is your favourite type of music?  
Please give an example
- What types of music do you dislike?  
Please give an example
- Do you regularly listen to music? (Y/N)  
If yes, when do you listen?  
What format is your listening in? (e.g. tapes, CDs, radio, live music)
- How many hours per day or hours per week do you spend listening to music?
- What type of listening do you use (active, passive or both)?

Figure A.1: Pre-admissions Clinic Questionnaire (cont.)