PSYCHOLOGICAL AND PSYCHOPHYSIOLOGICAL EFFECTS OF AUDITORY AND VISUAL STIMULI DURING VARIOUS MODES OF EXERCISE

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by

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Abstract

This research programme had three principal objectives. First, to assess the stability of the exercise heart rate-music tempo preference relationship and its relevance to a range of psychological outcomes. Second, to explore the influence of two personal factors (motivational orientation and dominant attentional style) in a naturalistic exercise-to-music setting. Third, to examine means by which to enhance the exercise experience above and below the ventilatory threshold. In Study 1, a mixed-methods approach was employed to capture responses to differing music tempo conditions across a range of exercise intensities. Results in Study 1 did not support a cubic relationship (Karageorghis et al., 2011) but rather a quadratic one, and there was a weak association between the optimal choice of music tempo and positive psychological outcomes. Music conditions reduced the number of associative thoughts by ~10% across all exercise intensities. Study 2 employed questionnaires with a large sample of female participants (*n* = 417) attending exercise-to-music classes. Results indicate that motivational orientation and attentional style (Association vs. Dissociation) influence responses to an exercise-to-music class. Study 3 examined the effects of external stimuli (music and video) on psychological variables at moderate and high exercise intensities. Findings served to demonstrate that manipulations of attentional focus can have a salient influence on affect and enjoyment even during high-intensity exercise. The contributions of the research programme include providing empirical evidence that attention can be manipulated during high-intensity exercise using theoretically-guided music selections, and music in combination with video footage, which enhance the exercise experience. Further, the research programme advances understanding of how motivational orientation and attentional style influence responses to music during exercise.

Dedication

To Claire, for everything.

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I find it challenging to articulate the extent of my gratitude towards all who have helped me. I hope everyone who has been there for me, and there are many of you, can understand the depth of my appreciation. Thank you.

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Chapter 1: Introduction to the Research Programme

The name of Pheidippides may not be widely known but the story of his feat is legendary. Each year, hundreds of thousands of people from across the globe seek to emulate his run and endure a stern test of mind and body. The story of Pheidippides, an Athenian soldier whose journey was most famously retold by Robert Browning in 1879, describes how he was sent from the Battle of Marathon against the Persian army to race to Sparta in search of aid. Upon his arrival in Sparta, he was told that the Spartans would not come to Athens' aid as a religious festival forbids them from engaging in war. Pheidippides set off to Athens and en-route sought to lift his spirits by recalling the names of the landmarks around him (*Yet "O Gods of my land!" I cried, as each hillock and plain, Wood and stream, I knew, I named, rushing past them again*) and when the route became most arduous he encountered an apparition: the Greek god Pan.

Pan reassured and inspired Pheidippides who continued his journey to Athens with renewed vigour (*the rest of my journey, I ran no longer, but flew. Parnes to Athens—earth no more, the air was my road*). Upon arrival to Athens and after two days and nights of running, an exhausted Pheidippides assured the Athenians that Pan would save their city and with his last breath declared "Athens is saved!". Robert Browning's poem is thought to have inspired the creation of the modern day marathon. In this legendary tale, Pheidippides engages with his surroundings and his own thoughts to help him complete his epic race. Ultimately, it is a moment of inspiration that lifted Pheidippides' spirit and motivated him to continue his race with increased fervour.

Although modern marathoners have access to some tools that were not at Pheidippides' disposal (e.g., carbohydrate gels, kinesiology tape, shock absorbing footwear, etc), they also use make use of one aid that was integral to the completion of Pheidippides' quest: distraction. The power of distraction during physical activity has long been acknowledged as a technique to cope with the physical symptoms of exercise. Pheidippides' use of self-talk during his arduous journey exemplifies one of a number of techniques that can be adopted as a distracter. Along with a wide array of technological advances since Pheidippides' quest, the capacity to listen to music during exercise offers an easily employed method of distraction. The capacity of music to capture the attention of listeners is one of the principal reasons underlying the effectiveness of music use during exercise (see Karageorghis & Priest, 2012a, 2012b). The question of how to maximise the psychological, psychophysical, and ergogenic outcomes of sport and exercise through the application of music has been intensely researched over the past 30 years, but music has been the subject of scientific enquiry for several decades prior to that (e.g., Ellis & Brighouse, 1952; Hyde & Scalapino, 1918).

1.1 Music in the Wider Context

Music is present on occasions ranging from religious ceremonies to warehouse raves and also still holds a place on fields of battle (see Pieslak, 2009). The development of music during the Early-to-Middle Ages was heavily controlled by religion and the expressionism we experience in modern music was not present in early musical works. Plato encapsulated the power of music and the place it holds within society "Music gives a soul to the universe, wings to the mind, flight to the imagination and life to everything". The artistic quality of musical arrangements continued to progress and the emotions music can capture and evoke were released by genius such as Mozart and Beethoven with their compositions. The capacity of music to elicit emotions is a topic of considerable interest to laypersons and professionals (Juslin & Sloboda, 2001). The context in which music is heard and the way a piece is composed can drastically alter its interpretation. Of the five basic components that contribute to a musical composition (melody, harmony, rhythm, tempo, and dynamics), it is rhythm and tempo that are most likely to elicit a physical response in the listener (Karageorghis & Terry, 2009). It has been suggested that a reason for the power of tempo and rhythm components is their relation to the various periodicities of human functioning such as respiration, heartbeat, and walking (Bonny, 1987). There are likely few people who can avoid tapping their foot in time to a funky soul track such as James Brown's *Get Up Offa That Thing*, or Rossini's *William Tell Overture*.

1.2 Music in Sport and Exercise

It has been suggested that sport and music share commonalities as they are both considered forms of entertainment, and are both ludic activities. As such, it is natural that they should interact with one another (Scowcroft, 2001). Socrates stated that a balance should be struck between music and gymnastics, as life comprising solely of music leads to softness and one of purely gymnasium leads to savagery.

> *The man who makes the finest mixture of gymnastic with music and brings them to his soul in the most proper measure is the one of whom we would most correctly say that he is the most perfectly musical and well harmonized* (Socrates, trans. 2000).

Höhne (1979) asserted the necessity of achieving a genuine synthesis of art and sport and that music is capable of enhancing physical culture and sport. Music has been increasingly associated with sport during the 20th and 21st centuries and the Olympic Games have been a significant driver in terms of reinforcing this association. Music can certainly be seen as an important factor in the development of the modern Olympics; Pierre de Coubertin envisaged that sporting activity and immersion in the arts could form a holistic partnership (Bale & Bateman, 2009). Musical performances were integrated at the inception of the modern Games in 1896 and continue to feature in events such as rhythmic gymnastics, synchronised swimming, and freestyle skiing. It is not only during Olympic events that music is played, but also throughout the opening and closing ceremonies. Music is prevalent at other large sporting events including the half-time show at the Super Bowl where the world biggest music superstars perform, and also smaller-scale events where bands and DJs play along the route of marathons to rouse the runners (e.g., Run to the Beat). Music has also been used with powerful effect during films that showcase sporting achievement. These include famous examples such as *Eye Of The Tiger* during Sylvester Stallone's training montage in *Rocky III*, and Vangelis' *Chariots Of Fire* during Eric Liddell and Harold Abrahams' training run by on a beach at St Andrews in Scotland. These tracks have gained renown in sporting contexts owing to their association with famous exploits, so much so that *Eye Of The Tiger* is frequently used at boxing events and *Chariots Of Fire* is often played as marathoners begin their race.

The combination of music and exercise was catapulted into mainstream society with the advent of technology that allowed people to listen to their music whilst running, cycling, roller-skating, and many other forms of exercise. Sony developed a personal stereo at the behest of the company's founder who wanted a stereo cassette player that he could carry with him. The release of personal stereo players by Sony in the late 1970s, and the subsequent release of the Sports Walkman was the first incidence of a portable music device being marketed at the exercising public.

Music is now pervasive within exercise contexts and with the improvements in technology a listener can access any track they wish, at any time of the day, from anywhere in the world. This pervasiveness is recognised, albeit for different reasons, by practitioners, researchers, and commercial companies alike who are seeking ways in which to maximise the relationship between music and exercise.

1.3 The Present Research Programme

A large and continually expanding body of literature is seeking to address the use of music in sport and exercise contexts. Owing to the growing body of literature that has increased dramatically in very recent years (13 papers were included in a review conducted in 1997 by Karageorghis and Terry, and this number increased to 62 in a 2012 review; Karageorghis & Priest, 2012a, 2012b) there are now two distinct research streams appearing with one focusing on sport and the other focusing on exercise and physical activity. The present research programme focused on the latter, although some of the implications are of relevance to sports training. Different research strands are also examining how the application of music before, during, or after exercise influences its effects; the present research programme focuses on music applied during an exercise task.

The evidence base for the psychological, psychophysical, and ergogenic effects of music is beginning to tell a story; a story with a narrative that music can be a powerful aid to exercise. The present programme of research includes exploration of how to maximise the effects of music during exercise and also examination of potential cognitive mechanisms underlying this effectiveness using an array of methodological and statistical approaches.

The first study of the programme builds upon a lineage of research examining the relationship between exercise heart rate and preference for music tempo

(Karageorghis, Jones, & Low, 2006a; Karageorghis, Jones, & Stuart, 2008; Karageorghis et al., 2011). This study seeks to further understand how music tempo, a factor acknowledged as a significant determinant of music preference (see North & Hargreaves, 2008), can enhance the exercise experience over a range of exercise intensities. The study examined the stability of the cubic (two points of inflection) relationship between exercise heart rate and music tempo preference found by Karageorghis et al. (2011). The relevance of this relationship was examined with regards to affect, flow, state attention, and intrinsic motivation, which was achieved through quantitative and qualitative methodological approaches.

The second study was couched in the conceptual frameworks of Karageorghis, Terry, and Lane (1999) and Terry and Karageorghis (2006) that have served to guide researchers in the music and exercise domain. The study seeks to gain further understanding of the antecedent personal factors that lead to potential benefits as listed in the 2006 model. The work acknowledges that personal factors are significant determinants of the effectiveness of music and examines how two psychological characteristics (motivational orientation and dominant attentional style) may influence the potential benefits of music use during exercise. This study moved away from the laboratory setting of the first study and entails quantitative data capture from participants attending exercise-to-music sessions at sports and leisure facilities in the southeast of England.

The third study explores mechanisms underlying the responses to music during exercise. The work was based on attentional models proposed by Rejeski (1985), Tenenbaum (2001), and utilises Ekkekakis's (2003) dual-model theory to examine the effects of music at exercise intensities above and below ventilatory threshold (the intensity at which a larger volume of carbon dioxide is expelled than the volume of oxygen consumed). Exercise intensity is thought to be a key determinant of affective responses and the study examined whether music, and also video, could be used as effective intervention strategies to enhance affect during moderate- and high-intensity exercise. The effects of the interventions were examined using psychological and psychophysiological measures. Such a study design can only be effectively undertaken with strict methodological controls to limit the influence of extraneous variables and therefore the study was executed in a laboratory.

Overall, this thesis includes an investigation of what would be the most appropriate music tempo to accompany a range of exercise intensities, an exploration of two psychological characteristics that may be deemed relevant personal factors in the relationship between music and a list of potential benefits, and an examination of underlying mechanisms that may account for the multifarious effects of music use during exercise.

1.4 Operational Definitions of Key Terms

The key terms included herein occur throughout the present programme of research and have been defined to facilitate understanding.

Affect: The subjective component of an emotional response to a stimulus which is accessible to an individual's consciousness, possessing both valance (positive or negative) and intensity/perceived arousal (strong or weak; Russell & Feldman-Barrett, 1999).

Arousal: Or activation, is the general bodily reaction associated with emotional changes, physical activity, rest, and alertness (Thayer, 1996).

Association: A focus on internal sensations such as body awareness and muscular tension (Tammen, 1996).

Asynchronous music: Application of music in the background to accompany sport/exercise-related activities where there is no conscious attempt from the individual to match their movements with the rhythmical qualities of the music (Karageorghis, 2008).

Dissociation: A focus on non-internal sensations such as conversations with others, listening to music, or imagining pleasant situations (Tammen, 1996).

Emotion: Emotions are (1) focused on specific events, (2) involve cognitive appraisal, (3) affect most or all bodily subsystems, which may become, to some extent synchronised, (4) are subject to rapid change, (5) have a strong impact on behaviour owing to specific action tendencies (Frijda & Scherer, 2009).

Ergogenic: The enhancement of work-output or engendering higher than expected power output, endurance or productivity (Karageorghis, 2008).

Flow: An optimal state involving altered awareness and total absorption in an activity (Csikszentmihalyi, 1990).

Mood: Moods are affective reactions distinct from emotions. Mood is an affective state of long duration, low intensity, and diffuse (Frijda, 2009).

Perceived exertion: A subjective estimation of physical exertion based upon Borg's Ratings of Perceived Exertion (RPE) scales (1982), which elicits a high correlation with heart rate and work intensity levels.

Psychophysical: The psychological perception of one's physical state (Karageorghis, 2008).

Psychophysiological: The relationship between psychological states and physiological measurement (Kent, 1998).

Rhythm: The feature of music relating to the periodical accentuation and distribution of notes.

Tempo: The speed at which a musical composition is played, measured in beats per minute (bpm).

Chapter 2: Review of Literature

The use of music during physical activity has never been more prevalent, and it is commonplace to see people in leisure facilities and parks using music as an accompaniment to their exercise activities. Many benefits associated with the use of music during exercise have been established (see Karageorghis & Priest, 2012a, 2012b for a review), but the need to further understand the mechanisms underlying these benefits and also ways in which to maximise them represent the next challenge for music and exercise researchers. Through a greater understanding of these two areas, researchers can help to positively shape the exercise experience. Moreover, music could prove to be a powerful ally to exercise in the fight against physical inactivity.

2.1 Overview of the Present Research Programme

The present research programme endeavoured to investigate how to maximise the effects of music use during exercise through a series of studies. Further, a greater understanding of the mechanisms underlying the effects of applying music during exercise was sought. Firstly, the most appropriate music tempo to accompany exercise was investigated through examining the stability of the relationship between exercise heart rate and music tempo preference. The relevance of the most preferred music tempo was examined in relation to a number of psychological outcome variables. Secondly, it is acknowledged that *personal factors* are significant determinants of preference and responsiveness to music in an exercise context (see Priest & Karageorghis, 2008: Karageorghis & Priest, 2012a, 2012b). The research programme included an exploration into the significance of an individual's contextual motivation and attentional style on the application of music during exercise. Thirdly, potential cognitive mechanisms underlying the psychological, psychophysical, and ergogenic effects of music were investigated through an examination of the effects that auditory stimuli, in comparison to and in conjunction with visual stimuli, can have on a range of measures (psychological and psychophysiological).

The body of literature that is reviewed herein seeks to encompass the complex interplay of music and the human organism with particular reference to the exercise context. The scope of this literature review seeks to include a variety of sources and topic areas that may shed some light on how researchers can maximise the benefits of music during exercise. There is evidence to suggest that the application of music during exercise can have a number of benefits including, amongst others, the capacity to capture attention, raise spirits, elicit emotional responses, alter mood states, function as an ergogenic aid, increase activation, and encourage movement (e.g., Karageorghis, 2008; Terry & Karageorghis, 2011).

2.2 Mood, Affect, and Emotion

Researchers have sought to examine changes in mood, affect, and emotion to further understand the dynamics of music use during exercise. It is imperative that a distinction is drawn between the mood, affect, and emotion and that the terms are not used interchangeably. A lack of distinction and the interchanging of these terms by researchers have likely contributed to the often equivocal findings in related literature (Beedie, Terry, & Lane, 2005). Ekkekakis (2013) artfully delineated these constructs and provided compelling evidence that the terms of affect, emotion, and mood are often misunderstood and used interchangeably throughout the literature. Ekkekakis warned that "there is a serious crisis, one that must be remedied before the full potential of this line of inquiry can be realized" (p. 32); the present programme of research will seek to avoid such pitfalls.

2.2.1 Differentiation between mood, affect, and emotion. There is a broad consensus among researchers that core affect is the most general of these concepts and can exist on its own but also underpins emotion and mood. Ekkekakis (2013) described how core affect is a broader concept than mood and emotion, and how core affect "provides the experiential substrate upon which the rich tapestry of moods and emotions is woven" (p. 40). Pre-eminent emotion researcher, James Russell, offered a definition of core affect as "the most elementary consciously accessible affective feelings (and their neurophysiological counterparts) that need not be directed at anything" (1999, p. 806). It has been proposed that the function of affective responses is based in evolutionary responses that signify a shift from a less valued to a more valued state (positive affect), or from a more valued to a less valued state (negative affect; Batson, Shaw, & Oleson, 1992). Russell (2003) described core affect as consciously experienced but not cognitive or reflective. Ekkekakis (2013) identified the noncognitive and nonreflective characteristics as the most defining of core affect. Core affect is a constant experience although the direction and intensity varies; examples include pleasure and displeasure.

Research on emotion has principally taken two approaches. One is viewing emotions as biological functions of the nervous system; the other views emotions as a psychological state, independent of underlying brain mechanisms (LeDoux, 1996). From the perspective of biological functioning, LeDoux stated that emotion does not refer to something that the brain has or does, rather emotion is a "convenient way of talking about aspects of the brain and its mind" (p. 16). There is scant research examining the emotions elicited by music and exercise from a strictly psychobiological perspective, with research focusing on emotions as psychological states.

Contemporary definitions of emotion comprise multiple interconnected components. Russell and Feldman-Barrett (1999), and Frijda and Scherer (2009) described emotions with reference to interrelated, yet distinct systems that coordinate and synchronise to form an emotion. Russell and Feldman-Barrett proposed that an emotional episode includes core affect; overt behaviour (e.g., fight with anger); attention towards, appraisal, and possible implications of the stimulus; prior experience of the emotion; physiological responses underlying an emotion (i.e., neural and chemical). Frijda and Scherer described how emotions involve a coordination of five systems: information processing, neurophysiological, executive, expressive, and experiential. Given the requirement of coordination and synchronisation between systems that constitute an emotion, the intensity tends to be high but the duration short. Emotions are directed at a stimulus, require appraisal, are of short duration but high intensity, and comprise multiple components; examples include *fear*, *shame*, and *pride* (Ekkekakis, 2013).

Moods share some commonalities with emotions but there are two key distinctions that separate them; duration and intensity. Ekman (1992) suggested that although emotions give the impression of lasting for a long time, it is often that multiple cases of emotion occur in succession. Ekman proposed that emotions last for seconds rather than minutes, hours or days, and moods last for hours or days. A commonality between mood and emotion is that they both stem from appraisal (Ekkekakis, 2013). However, whereas emotions occur temporally close to the stimulus, a mood is more remote. Ekman described how people can often specify the event that triggered an emotion, but can rarely do so for a mood. Frija (2009) describes the diffuseness of mood by suggesting that even when an event has elicited a mood, the mood state is not felt about the event even though the individual is aware of the event that caused it. Further, Frija suggested that moods can be the after effects of pleasant or unpleasant emotional events. Ekkekakis offered tentative distinction between mood and emotions by suggesting that moods are of greater duration and of lower intensity than emotions, and the object of appraisal is not necessarily identifiable. Examples of moods include *irritation*, *cheerfulness*, and *grumpiness*.

It is important that terms and concepts used within the sport and exercise psychology are consistent and in line with definitions used in other domains (e.g., affective psychology). There are several examples in the exercise literature where measurement of emotions have been used to infer moods (e.g., Bodin & Martinsen, 2004; Herring, O'Connor, & Dishman, 2010), and such inconsistencies have led to a lack of conceptual clarity (Beedie at al., 2005).

2.3 Early Exercise-Related Investigations into the Effects of Music

While research into the benefits of music on exercise-related tasks has received increasing attention over the past four decades, research prior to the mid-1990s produced equivocal results that have been attributed mainly to methodological limitations and a lack of conceptual frameworks (see Karageorghis & Terry, 1997). Early research in this area (pre mid-1990s) focused on a range of effects including psychophysiological functioning, affective responses, and motor performance.

Preliminary investigations into effects of music focused primarily on physiological measures (principally heart rate) or psychophysical measures (ratings of perceived exertion; RPE). Ellis and Brighouse (1952) conducted a study to investigate how different types of music affected the physiological measures of heart rate (HR) and respiratory rate (RR). The three music selections made by Ellis and Brighouse used in the experimental protocol were described as "subdued jazz", "soothing classical", and "dynamic classical". Given the emergence of Rock and Roll music in late 1940s and early 1950s America (where the study was conducted), with artists such as Little Richard and Fats Domino, the music selection may not have been entirely appropriate for undergraduate college students. The music did have a significant effect on RR with the dynamic classical selection causing greater increases in respiration than the other selections, but the music did not significantly affect HR. Ellis and Brighouse concluded that music may be used as a therapeutic aid to increase RR but that music also has limitations as a therapeutic aid insomuch that changes in HR remained nonsignificant. Interestingly, the authors suggested that the magnitude of the response is specific to the music employed and they also acknowledged that the effects of music are highly complex.

Zimny and Weidenfeller (1963) continued the exploration of physiological responses to music with their investigation into the effects of "exciting", "neutral", and "calming" music on HR and galvanic skin response (GSR). They suggested that changes in these two variables were physiological manifestations of emotional response. The music selected was stated as having the capacity to stimulate different responses (to excite, and to calm) and was drawn from the classical genre. A difference between Zimny and Weidenfeller's and Ellis and Brighouse's (1952) studies was that participants in the former were asked to rate each piece of music (although it is not said how they were rated), a procedure that substantiated the earlier judgements that the music selections elicited different responses of excitement and calm. The music selection designed to elicit excitement did lead to a significant effect on GSR, suggesting an increase in arousal; however, the calming and neutral selections did not differ. Similar to the findings of Ellis and Brighouse, there was no effect on HR, but GSR did differ across conditions. This led Zimny and

Weidenfeller to advise that GSR, rather than HR, should be employed as a dependent measure when examining the emotional effects of music.

The investigative work of Ellis and Brighouse (1952), and Zimny and Weidenfeller (1963) had focused on physiological responses of listening to music during a relaxed state (sitting and listening to music) but a number of studies (e.g., Boutcher & Trenske, 1990; Copeland & Franks, 1991; Dorney, Goh, & Lee, 1992; Schwartz, Fernhall, & Ploughman, 1990; Uppal & Datta, 1990) sought to shift this this line of investigation into an exercise context. Boutcher and Trenske investigated the effects of sensory deprivation and music conditions on psychophysical (ratings of perceived exertion), psychological (affect), and psychophysiological (HR) outcomes across low, moderate, and high exercising intensities. Similar to work outside of the exercise context, they did not find that HR differed significantly between music and sensory deprivation conditions. In their 1990 study, Schwartz et al. examined the effects of music during cycle ergometry using a raft of physiological measures (HR, VO_2, V_E, and RER). Their findings led them to refute the notion that listening to music during exercise elicited any physiological changes, as none were found in their study. It has since been suggested that the invasiveness of the physiological measures detracted from the music experience and this might have negatively influenced the effects of music (Karageorghis & Priest 2012a).

During the early 1990s a number of studies combined physiological measures with psychophysical measures in order to further understand the effects that music can have in an exercise context (e.g., Copeland & Franks, 1991; Schwartz et al., 1990). However, much of this work was blighted by serious methodological flaws. Karageorghis and Terry (1997) presented a critique of music research in sport and exercise and highlighted several issues that may have accounted for the equivocal results found up to that point.

Karageorghis and Terry (1997) summarised the main weaknesses with the earlier investigations as: insufficient consideration as to the socio-cultural background of the participants, imprecision during music selection or failing to report the selected music, inconsistencies regarding temporal elements such as duration of music exposure or when music was played relative to the experimental task, non-reporting of sound intensity (volume) for music used in experimental tasks and non-standardisation of this across tracks and conditions, inaccurate use of music terminology in sport and exercise literature, and the use of inappropriate performance measures.

More recent research (post-1999) has sought to address many of the short-comings that plagued earlier work. The equivocal results relating to the application of music in the exercise domain have lessened and a more coherent picture has begun to emerge. The development of conceptual frameworks to help guide researchers and address the paucity of a guiding theory in the domain has, in part, helped to overcome the earlier limitations (e.g., Atkinson, Wilson, & Eubank, 2004; Crust, 2004; Crust & Clough, 2006).

2.4 Conceptual Frameworks

Conceptual frameworks have provided a focal point for research examining the effects of music in sport and exercise contexts. Two frameworks are presented here and an additional framework is presented in Section 2.5.1 relating to the use of music prior to a sporting activity.

2.4.1 The 1999 conceptual model. Karageorghis et al. (1999) proposed a framework for predicting the psychophysical effects of asynchronous music in sport and exercise contexts (see Figure 2.1). Asynchronous music refers to the lack of conscious synchronisation between movement and music tempo. It was proposed that four factors contributed to the motivational qualities of a piece of music: rhythm response, musicality, cultural impact, and association. These were further divided into two groups: internal/music factors (rhythm response and musicality) and external/personal factors (cultural impact and association). The internal factors refer to the structure of the music, whereas external factors pertain to how an individual interprets the music.

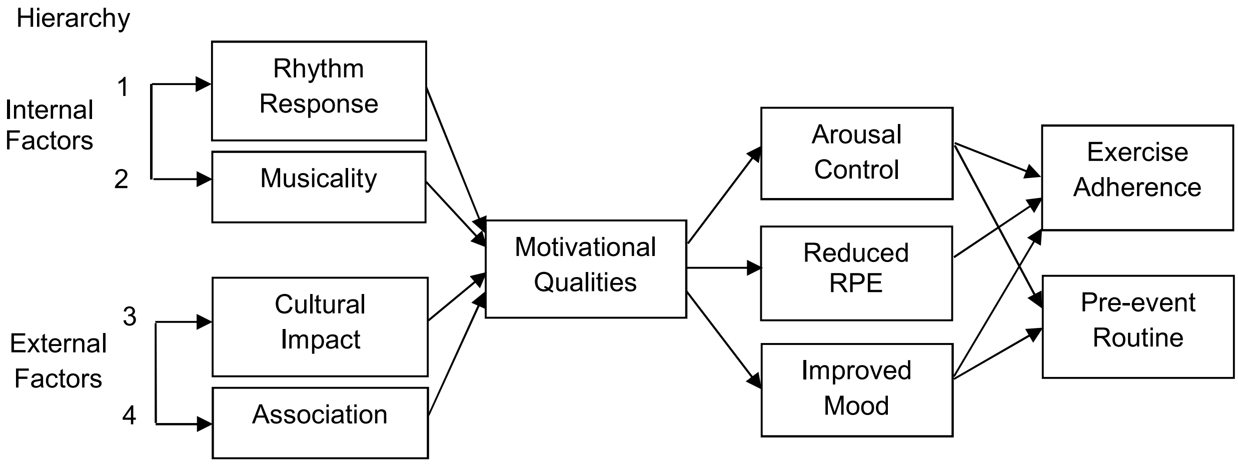

Figure 2.1. Conceptual framework for the prediction of responses to motivational asynchronous music in exercise and sport (Karageorghis et al., 1999). Reprinted from "Development and Initial Validation of an Instrument to Assess the Motivational Qualities of Music in Exercise and Sport: The Brunel Music Rating Inventory" by C. I. Karageorghis., P. C. Terry., and A. M. Lane, 1999, *Journal of Sports Sciences*, *17*, p. 721. Copyright 1999 by Taylor & Francis Ltd.

Rhythm response relates to the natural responses an individual may have towards the rhythmical and temporal elements of music, especially tempo (Karageorghis & Terry, 2009). Tempo refers to the speed of the music and is measured in beats per minute (bpm). Musicality includes pitch-related (as opposed to rhythm related) elements such as melody and harmony which help to shape the mood of the music. Juslin (2009) presented a list musical factors that are associated with various emotional responses and tempo was the initial factor in the criteria for the determination of emotional responses. Following tempo, the mode (major or minor), and pitch were strong determinants of emotional response. For example, a track with the following music factors is likely to elicit a happy response: fast tempo, small tempo variability, major mode, simple and consistent harmony, high pitch. Further, a track with a slow tempo, minor mode, and low pitch are likely to induce sadness.

Cultural impact concerns the pervasiveness of music within society or a specific sub-group of the population. Specifically, frequent exposure to musical styles increases familiarity and this is in accordance with the notion that familiarity has a significant influence in determining music preference (Berlyne, 1971). North and Hargreaves (2008) explained that a relationship between liking and familiarity is somewhat inconsistent but there is a trend that suggests there is an inverted-U relationship between liking and familiarity. Association draws upon the extra-musical associations that music may evoke; a prime example of this is Vangelis's *Chariots Of Fire* and its connection to Olympic glory (Karageorghis & Terry, 2009). These associations are built by repetition and powerful images on television, cinema, radio, and online. The association between a piece of music and a sporting activity has been described as a conditioned response (Karageorghis, 2008). This conditioned response is the result of repeated exposure to a piece of music related to a specific situation or context; for example, if a football (soccer) fan hears Tony Britten's arrangement of Handel's *Zadok The Priest*, they will likely respond with excitement as this tune is played before every UEFA Champions League fixture.

Karageorghis et al. (1999) suggested that internal factors relating to the musical structure of a track are of greater significance in determining the motivational qualities than external factors. The hierarchical structure was the product of an exploratory structural equation modelling approach wherein the 13-item, four factor structure accounted for 59.2% of the variance. Karageorghis and Terry (2009) elaborated on the order of the hierarchy and suggested that motivational music has a tempo above 120 bpm, a catchy melody, inspiring lyrics, an association with sporting endeavour, and an uplifting harmonic structure. Karageorghis and his colleagues developed an inventory alongside this conceptual model that would assist in quantifying the motivational qualities of a track.

2.4.2 Music rating. The initial Brunel Music Rating Inventory (BMRI; Karageorghis et al., 1999) was developed in order to operationalise the 1999 conceptual model. The inventory was designed to address the lack of tools available to identify the motivational qualities of music. Following a five-stage procedure that included structural equation modelling, the BMRI was developed with acceptable evidence pertaining to factorial validity and borderline reliability (Cronbach's Alpha ranging from .57 to .87). The authors acknowledged limitations and weaknesses with the inventory and these became more apparent following additional research and application of the BMRI (see Karageorghis, Priest, Terry, Chatzisarantis, & Lane, 2006b). Principally, the instability and low reliability of several items within the instrument provided cause for concern. Further, the familiarity items was weakly correlated with the cultural impact factor that it was designed to reflect. Another limitation of the BMRI was that it was developed to be used exclusively by experts in music selection for exercise (e.g., aerobics instructors) and was not designed for use by exercise participants. The instrument underwent significant redesign and revalidation and the BMRI-2 (Karageorghis et al., 2006b) was developed to address the limitations identified in the structure and application of the BMRI.

The BMRI-2 was designed through a five-stage process that included both qualitative and quantitative techniques. Karageorghis et al. (2006b) aimed to redesign the BMRI around the action, time, context, and target guidelines suggested by Azjen and Fishbein (1977). The BMRI-2 was concerned with motivation (action) during (time) exercise (context) and the target was the constituents of the music (e.g., tempo and melody). Each item on the BMRI-2 followed a similar form (e.g., “The tempo of this music would motivate me during exercise”; “The melody of this music would motivate me during exercise”) and responses were provided on a 7-point Likert scale anchored by *Strongly Agree* and *Strongly Disagree*. Karageorghis (2008) later presented the BMRI-3 that included slight modifications to the BMRI-2. The BMRI-3 was designed to be used to rate the motivational qualities of music in a variety of exercise and sport contexts (Karageorghis).

A concern that remains with the inventory is whether users sufficiently understand the differences among the constituents of music. The vast majority of exercise participants, who are targeted as users, will not have formal music training. Karageorghis and his collaborators appear to have attempted to avoid any such confusion by offering a more generic term next to the property being questioned (e.g., melody [tune], or tempo [speed]). The inclusion of such explanatory terms indicates some acknowledgement by the authors of the possible confusion that may arise in trying to delineate the components of a piece of music.

The BMRI and its subsequent upgrades have been used in a number of studies (e.g., Atkinson et al., 2004; Crust & Clough, 2006; Hutchinson et al., 2011). The scores from the inventory lead to the categorisation of a music track as either motivational or *oudeterous*. The term *oudeterous music* was operationalised in the development of the initial BMRI, and it relates to music that is neither motivating nor demotivating (Karageorghis et al., 1999). Karageorghis and Terry (2011) provided guidelines for BMRI-3 scores to identify tracks with high motivational qualities, moderate motivational qualities, and tracks lacking in motivational qualities (p. 211).

In the development of the BMRI-2, the authors acknowledged that "aspects of aesthetic experience transcend scientific evaluation; however, the brevity and simplicity of the BMRI-2 mean that large quantities of music can be rated on a scale that permits comparisons between the responses of different subgroups." (p. 907). This acknowledgement led to the development of qualitative guidelines that should be used in conjunction with the BMRI-2 to identify tracks that might be considered motivational for a given individual or subgroup of the population.

2.4.3 The 2006 conceptual model. There was a sharp increase in the amount of research conducted into the effects of music in exercise and sport following the conceptual framework and development of the BMRI by Karageorghis and colleagues (1999; e.g., Elliott, Carr, & Savage, 2004; Hayakawa, Miki, Takada, & Tanaka, 2000; Pates, Karageorghis, Fryer, & Maynard, 2003; Tenenbaum et al., 2004). The majority of this work focused on the benefits, or consequences, of listening to music before or during an exercise or sporting activity. This increase in the number of studies led to greater evidence in support of the benefits related to the use of music to enhance psychological, psychophysical, and ergogenic outcomes. The list of potential benefits grew to include: dissociation; enhanced work output; greater skill acquisition; enhanced likelihood of achieving flow state; an increase in performance. Terry and Karageorghis (2006) presented a revised conceptual framework (see Figure 2.2) that sought to encapsulate this burgeoning list of benefits.

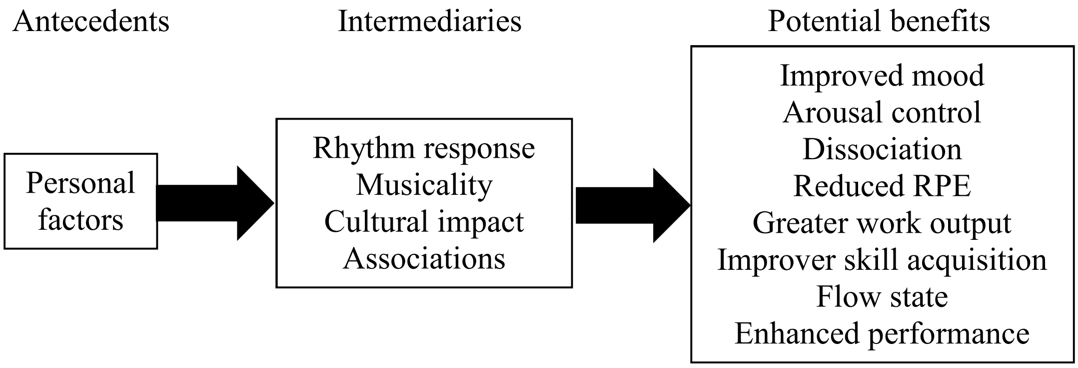

Figure 2.2. Conceptual framework for benefits of music in sport and exercise contexts (Terry & Karageorghis, 2006). Reprinted from "Psychophysical Effects of Music in Sport and Exercise: An Update on Theory, Research, and Application." by P. C. Terry, and C. I. Karageorghis, 2006, In M. Katsikitis (Ed.), *Psychology bridging the Tasman: Science, culture and practice – Proceedings of the 2006 Joint Conference of the Australian Psychological Society and the New Zealand Psychological Society*, p. 416.

The revised conceptual model adopted a different approach to its predecessor with personal factors included as antecedents. This represented a shift in approach that gives primacy to personal factors over the internal and external factors present in the 1999 conceptual model. However, this raises some uncertainty as to what these personal factors specifically relate to; the 1999 and 2006 model include *external factors* (meaning they are associated with the listeners interpretation of the music and their musical experiences [Karageorghis, 2008]), which suggests that the personal factors relate to other indices such as age and personality (North & Hargreaves, 2008).

The 2006 model presents the list of potential benefits without explicating the precise context in which these are achieved. The redesign of the operationalisation of the 1999 conceptual model (the BMRI-2) represented a step forward in the sophistication of the approach to the application of music in exercise and sport. The use of *action*, *time*, *context*, and *target* (cf. Karageorghis et al., 2006b) led to a more accurate instrument for the identification of the motivational qualities of music, but such specificity is not evident in the 2006 conceptual model. The list of benefits presented relate to both sport and exercise contexts and it may have been appropriate to specify within the model whether evidence had been found to support the inclusion of those benefits in sport contexts and exercise contexts separately.

Further differences between the 1999 and 2006 conceptual models include testable hypotheses to emanate from them. The 1999 model presented testable hypothesis owing to clear linkage between components. For example, a study could have examined the veracity of the link between reduced ratings of perceived exertion and exercise adherence. However, the 2006 model did not provide a schema for such clearly testable hypotheses. Additionally, the 1999 model was concerned with the asynchronous use of music (in-task) whereas the 2006 model included benefits from the application of music both pre-task and in-task music, which also embraces its synchronous application. The timing of when music is applied has been shown to have differing effects but these were not identified in the model, however the evidence for the differing effects was discussed in supporting text (see Terry & Karageorghis, 2006).

The separation of music and personal factors in determining responsiveness to music is not exclusive to the use of music in sport and exercise. Hargreaves, Miell, and MacDonald (2005) presented a model that sought to encapsulate the main influences on music responsiveness; these included the music, the listener, and the listening situation. The models presented by Karageorghis et al. (1999) and Terry and Karageorghis (2006) have attempted to encapsulate these three influences in the domain of sport and exercise.

2.5 The Application of Music

There are four areas of research that have developed where music has been applied to sport and exercise activities at different time points: before, during, and after. The application of music during an activity (in-task music) has been the most comprehensively researched of these three time points and this branch of research has subsequently divided into two; the synchronous and asynchronous application of music. The following sections seek to elaborate on the effect that music can have on sport and exercise when applied at different time points.

2.5.1 Pre-task music. Many individuals and teams have used music as part of their pre-event routine. For example, Team Sky Pro Cycling plays a selection of music on the team bus before each stage of the Tour de France (http://tech.uk.msn.com/features/tour-de-france-2013-cycling-gear-to-turn-you-into-chris-froome?page=11). The playlist includes tracks selected by each member of the team, and even a cursory examination of this playlist exemplifies the difference in individual preferences in music selection when preparing for an event. Pre-task music can be used as a stimulative or sedative aid (Karageorghis & Terry, 2009) and the range of tracks included by members of Team Sky Pro Cycling team members exemplifies how people utilise different styles of music to regulate their emotions. The playlists, which include the tracks *Get Down* by Nas and *Feelin' Alright* by Joe Cocker, emphasise the difficulty that a practitioner would face when attempting to compile an appropriate pre-event playlist in a team environment.

There have been relatively few studies examining the effects of pre-task music in sport and exercise. A study by Karageorghis, Drew, and Terry (1996) sought to build upon a preliminary investigation of pre-task music on grip strength by Pearce (1981). Karageorghis et al. found that participants produced significantly higher hand-grip dynamometer scores after listening to stimulative music compared to sedative music or a white noise control. The stimulative and sedative qualities of the music employed by Karageorghis et al. (1996) were rated using a music rating tool and the track selections were made with regard to familiarity, and socio-cultural background. However, the duration of the tracks was not standardised (230 s for stimulative tracks and 190 s for sedative track) and presents a threat to internal validity that may account for some of the difference found between them.

Pates et al. (2003) sought to explore psychological and performance effects whereas previous work examining the influences of pre-task music had focused on the psychophysiological effects (e.g., Hall & Erickson, 1995). Pates et al. investigated how flow state and netball shooting performance were influenced by self-selected music listened to immediately before the task. Their study adopted an idiographic approach that offered a different approach from other music and exercise research that predominantly adopted a nomothetic approach. The music condition led to an increase in shooting performance and an increase in flow state which led the authors to conclude that the self-selected music enhanced performance by triggering emotions and cognitions associated with flow. The application of self-selected music presented a relatively uncommon approach for research at this time, and the debate between self-selected and prescribed music remains a contentious issue (see Section 2.9.1.1).

To extend the research examining the ergogenic effects of pre-task music, Yamamoto et al. (2003) and Eliakim, Meckel, Nemet, and Eliakim (2007) examined the effects of pre-task music on a supramaximal task. Yamamoto et al. reported no differences in power output during a Wingate test when participants listened to either "slow or fast rhythm music for 20 min" (p. 211). The music used prior to the Wingate test was selected by the researchers, but it appears that scant attention was given to the methodological suggestions of Karageorghis and Terry (1997). The "slow rhythm" condition included a selection of classical music by Chopin, and the “fast rhythm” condition consisted of music from Hollywood movies (e.g., *Top Gun* and *Rocky*). These music selections may not have been appropriate for Japanese undergraduate students and this may have contributed to the lack of difference between the conditions. Further, no data was presented for a control condition (no-music) and this omission leads to the question of whether both music conditions would have increased power output compared to a no-music control, which would have led to very different conclusions. Eliakim et al. built upon the work of Yamamoto et al. and found a significant difference in peak power between a music condition and a no-music control condition. The music condition used by Eliakim et al. was somewhat more appropriate than that employed by Yamamoto et al. and tracks of 140 bpm were selected from a playlist designed for a Spin class which likely promoted greater congruence between the music and task (see Karageorghis et al., 2006b).

Luakka and Quick (2013) conducted a large-scale study that investigated the motives of elite athletes’ use of music in sport. The questionnaires employed in the study sought to assess the prevalence of various uses of music, and included open-ended items that targeted specific emotional episodes (e.g., happy, confident, focused). The results showed that elite athletes used music in a comprehensive manner throughout pre-event preparations, warm-up directly before competition, and training sessions. The most frequently reported motives for listening to music in sports were to increase levels of activation, motivation, performance, and positive affect. In support of the work by Bishop, Karageorghis, and Loizou (2007), the results indicated that music is often used during pre-event preparations but less so during competition or after the event.

Bishop et al. (2007) presented a comprehensive framework that sought to encapsulate the use of music as part of a pre-task routine. The framework was based on the pre-performance routines of young tennis players and was constructed using the results of questionnaires, interviews, diaries, and observations with 14 players. The model described five determinants of emotive music as the entry point for the model. These five determinants were not presented in a strict hierarchical structure, as Karageorghis et al.'s (1999) model was, owing to different data collection techniques. However, extra-musical associations and influences from significant others featured heavily in the responses of the tennis players. Bishop et al. aligned these determinants with Scherer and Zentner's (2001) central routes of emotion induction, but the order contrasted with the hierarchical structure of Karageorghis et al. where such factors (e.g., extra musical association) were placed below music factors. This indicates that the process of selecting tracks for use prior to an activity may differ from that of selecting a track for in-task use during exercise. Regardless of the different order of determinants, the consequences listed in the model by Bishop et al. are of a similar nature to that of music used in-task (e.g., enhanced affect, dissociation, and arousal regulation).

The influence that pre-task music can have on psychophysical, psychological, and performance outcomes is significant. Crust (2004) presented one of the few studies that have compared the effects of pre-task music and in-task music on a performance outcome (length of time completed for an isometric weight-holding task). Results showed that in-task music was more effective than pre-task music for an isometric weight-holding task with participants holding the weight for 12 s longer when exposed to music for the entire trials, which was associated with a moderate effect size ($d = .6$). Crust suggested that the effects of music exposure prior to a task are relatively short-lived. The music used in the experimental trials was based on the recommendations of Karageorghis et al. (1999), which were designed for in-task music, so perhaps it is not entirely unexpected that in-task music led to greater performance.

2.5.2 In-task music. In-task music can be applied synchronously or asynchronously. The synchronous application of music requires the participant to consciously synchronise their movement during an activity with the rhythmical aspects of music (e.g., tempo; Karageorghis, 2008). The majority of research examining the effects of in-task music has focused on the asynchronous application but there are a number of studies that have explored the synchronous application.

2.5.2.1 Synchronous music. Several studies have shown the effectiveness of synchronous music in influencing psychological, psychophysical, and ergogenic outcomes during physical activity (e.g., Bacon, Myers, & Karageorghis, 2012; Simpson & Karageorghis, 2006). Several possible mechanisms underlying the propensity for humans to work "in-time" with a beat have been proposed. The rhythmic response to music appears to be a genetic predisposition (Patel, 2008). It has been proposed that a central "pattern generator" or pacemaker in the brain may serve to regulate temporal functioning and govern the "rhythm response" (Schneider, Askew, Abel, & Strüder, 2010). It is postulated that this mechanism coordinates afferent nerve signals with their efferent counterparts that control movement and also regulate locomotion, neurovascular control, and sensory integration. The pattern generator may be associated with an aspect of the central nervous system known as *time form printing*, which concerns the propensity to execute repetitive patterns of movement (e.g., running) following only an initial command requiring specific attention (Clynes & Walker, 1982). Regardless of its role in activating a pacemaker or pattern generator, music may stimulate parts of the brain that govern arousal, specifically the limbic and reticular activating systems (Lyttle & Montagne, 1992; Neher, 1962).

Synchronicity between movement and music may lead to beneficial outcomes via a process referred to as *auditory-motor synchronization* (see Chen, Penhune, & Zatorre, 2006). This process has only recently been discussed in the sport and exercise literature and recent studies have found that exercising in synchrony with music may lower the metabolic cost of the activity by promoting greater neuromuscular and kinetic efficiency (e.g., Bacon et al., 2012; Roerdink, 2008; Terry, Karageorghis, Mecozzi Saha, & D'Auria, 2012).

Simpson and Karageorghis (2006) examined the effects of synchronous music on 400-m running time trial performance and found significant improvements in performance during the synchronous music condition compared to a no-music control ($\eta_p^2 = .24$). Terry et al. (2012) found similar results when examining elite triathletes completing a treadmill run. This was the first study to use elite athletes and highlighted the efficacy of synchronous music for elite as well as non-elite populations. Terry et al. found that numerous benefits were associated with the triathletes synchronising their movements to the beat of the music, including: longer time to exhaustion, lower RPE, lower blood lactate concentrations, lower oxygen consumption, and better running efficiency. However, the benefits of synchronous music are not found in all activities.

A study by Karageorghis et al. (2010) found that synchronising with music during circuit-training did not increase the amount of repetitions completed compared to a no-music control condition, and affective valence did not significantly increase. The authors proposed that synchronous music is more likely to exert a significant influence on performance when "there is the possibility for it to influence voluntary performance as in a gymnasium-type "workout" rather than a strictly-controlled exhaustive effort" (p. 557). They also reported that affective valence showed no significant difference between experimental and control conditions owing to data being collected post-task rather than in-task. This suggestion is in-line with findings of Ekkekakis, Hall, and Petruzzello (2008), Parfitt, Rose, and Burgess (2006), Rose and Parfitt (2010), and Sheppard and Parfitt (2008) who found that affect rebounded to baseline levels almost immediately post exercise.

2.5.2.2 Asynchronous music. A far greater number of studies have examined the effects of asynchronous music during physical activity. Szmedra and Bacharach (1998) focused predominantly on physiological benefits of asynchronous music during submaximal treadmill exercise. The music condition comprised a medley of excerpts from popular classical songs that maintained a tempo of 123 bpm. They found that the music condition led to a reduction in heart rate, systolic blood pressure, lactate production, and norepinephrine production. The single psychophysical measure included in the design showed that ratings of perceived exertion (RPE) were 10% lower during the music condition compared to control. In support of the influence on RPE, Nethery (2002) found a similar reduction while listening to self-selected asynchronous music during cycle ergometry.

The influence of asynchronous music has been examined across exercise modalities (e.g., treadmill and cycle ergometry). Atkinson et al. (2004) utilised a 10-km cycle time trial task to examine the influence of asynchronous music and found that music improved the time trial results, but led to an increase in RPE. Their participants did work harder but, in contrast to previous work (e.g., Nethery, 2002; Szmedra & Bacharach, 1998) music did not reduce perceived exertion. Therefore, participants were working harder but were fully aware of this; a finding that adds to the evidence pertaining to the ergogenic effects of asynchronous music. Tenenbaum et al. (2004) explored the psychophysical and physiological effects of asynchronous music on treadmill and cross-country running. They did not find significant differences for heart rate or RPE between the music and no-music conditions, but 30% of participants indicated that the music helped them at the start of the run. Participants stated that "music both directed their attention to the music and motivated them to continue" (Tenenbaum et al. p. 89). Further, participants perceived the music as beneficial despite the heavy workload that was employed. These results hint at the potential for asynchronous music to positively shape the exercise experience (cf. Karageorghis & Terry, 1997).

Asynchronous music has been examined across a range of exercise intensities and the results appear to indicate a reduction in its effects once intensity approaches maximal levels (e.g., Pujol & Langenfeld, 1999; Tenenbaum et al., 2004). However, a study by Hutchinson et al. (2011) demonstrated that asynchronous music may be of benefit during a supramaximal task. Hutchinson et al. assessed the influence of an experimenter-selected track on RPE, affect, motivation, and power output during a Wingate test. The music condition resulted in more positive affect, greater levels of motivation, and increased power output compared to the no-music control. The authors suggested that the effects of music may be limited to the initial burst of an activity; a suggestion that seems to be supported by other findings (e.g., Atkinson et al., 2004; Tenenbaum et al.,).

2.5.2.3 Synchronous vs. asynchronous music. There have been a number of studies that have sought to directly compare the effectiveness of synchronous and asynchronous music during physical tasks. The first such study, conducted by

Anshel and Marisi (1978), found that synchronous music yielded longer endurance on a cycle ergometry task than asynchronous music and a no-music control condition. However, the music was selected without consideration for the preferences of the participants and this was common among preliminary investigations into the effects of music and exercise (see Karageorghis & Terry, 1997). Contemporary investigations have sought to more fully incorporate appropriate music selections into their designs (e.g., Atkinson et al., 2004; Karageorghis et al., 2011). Bacon et al. (2012) directly compared the effects of a slow asynchronous track (123 bpm), a synchronous track (130 bpm), and a fast asynchronous task (137 bpm) while participants cycled at 70% max HR at 65 rpm. Results indicated that exercise with synchronous music led to lower mean VO_2 compared to the slow asynchronous track but results for RPE were non-significant. These results indicate that exercise is more efficient when performed synchronously with music than when musical tempo is slightly slower than the activity.

There is evidence that both synchronous and asynchronous application of music during exercise lead to positive psychological, psychophysical, and ergogenic benefits (e.g., Crust, 2004; Karageorghis et al., 2008; Karageorghis et al., 2009). Synchronous music has more consistent findings related to efficacy during high intensity exercise, with specific regard to efficiency (e.g., Terry et al., 2012). The benefits of synchronous and asynchronous music have been shown for elite and recreational populations (e.g., Terry et al.; Waterhouse, Hudson, & Edwards, 2010), but it is the application of asynchronous music that may be more appealing for use with recreationally active populations. A primary reason for the use of music during exercise is motivation (see Priest & Karageorghis, 2008), and to date there is greater evidence that asynchronous music is motivational during exercise (e.g., Hutchinson et al., 2011; Karageorghis et al., 2008) compared to synchronous music.

The ease of use with which asynchronous music can be applied represents a significant advantage over synchronous music. Synchronous music is specific to an activity (e.g., cycling rpm or running cadence) and requires longer preparation time than asynchronous music. If synchronous music is applied, it does not allow for any individual freedom, which can be a key aspect of exercise. Although the increased efficiency is a distinct benefit of synchronous music compared to asynchronous music, this is unlikely to be an appealing factor for a recreationally active population. Further, a synchronous playlist would have limited variety owing to an exact beat that must be present throughout the whole workout. This limitation is likely to be exacerbated when accounting for other (personal) factors (i.e., socio-cultural background) that may lead to the pool of available tracks to reduce dramatically. Karageorghis and Priest (2012b) highlighted the importance of the *churn* of a playlist, and a diminished pool of available tracks will limit the opportunities to refresh the playlist.

2.5.3 Post-task/recuperative music. There have been few investigations into the effects of applying music as a post-task recovery aid. Jing and Xudong (2008) conducted one of the first explorations into the effects of sedative music on recovery, using a 15-min exhaustive cycle ergometer trial as the activity. The sedative music condition led to decreases in HR, urinary protein, and RPE but did not lead to changes in jump height, blood glucose, blood lactate, and reaction time compared to no-music. The usefulness of some of the measures employed by Jing and Xudong can be questioned, but the study did offer some evidence that music can have an effect post-exercise.

The results of Jing and Xudong received support from Savitha, Mallikarjuna, and Chythra (2010) who employed *slow* and *fast* music after submaximal treadmill exercise. They found a significant decrease in blood pressure and heart rate with the slow music compared to the fast music and control conditions. There appears to be some confusion in the reporting of the music applied by Savitha et al. as it is stated that the slow music condition was less than “100db” [*sic*] and the fast music condition was more than “200db” [*sic*]. Even accounting for mistaking db (decibels) for bpm (beats per minute) it seems unlikely that tracks in excess of 200 bpm were used in the study owing to the rarity of these tracks and the complete lack of rationale for the use of such music. There are several other significant flaws in these initial studies, such as a lack of counterbalancing, but they offer support for the notion espoused by Terry and Karageorghis (2011) that sedative music is appropriate as a recuperative aid. Terry and Karageorghis suggested that recuperative music should be in the tempo range of 60–70 bpm, with a neutral valence, include instrumentation such as strings or gentle piano, and avoid complex arrangements.

Two studies have investigated the efficacy of motivational music as a post-task recovery strategy (i.e., Eliakim, Bodner, Eliakim, Nemet, & Meckel, 2012; Eliakim, Bodner, Meckel, Nemet, & Eliakim, 2013). The 2012 study by Eliakim and colleagues found that music described as motivational (popular music that is commonly used in gymnasia and had a tempo of 140 bpm) encouraged participants to engage in a more active recovery than no-music and therefore led to reduced blood lactate and RPE over a 15-min recovery period. In a similar study, Eliakim and colleagues (2013) isolated the rhythmical component of the tracks used in their 2012 study and found that this led to a more active recovery (and subsequently reduced blood lactate) compared to no-music, but was not as effective as the motivational music tracks. Eliakim et al. (2012; 2013) suggested that music is an important tool to aid recovery following an intense bout of exercise, and that fast tempo music is most appropriate.

There appear to be two differing approaches to examining the effects of post-task music. One approach adopts sedative music as a means of relaxation, whereas the other approach seeks to utilise the motivational properties of music to conduct an active recovery. This new territory for music and exercise researchers provides avenues for creative studies and offers opportunity for multi-disciplinary research (in particular with exercise physiology) to help guide the most appropriate recovery strategies. For example, Spierer, Goldsmith, Baran, Hryneiwicz, and Katz (2004) exemplified the common understanding that an active, rather than a passive recovery, is most appropriate following exercise. However, cessation of activity and a relaxed state may be more beneficial if a quick recovery is not essential (e.g., immediately post-marathon). In essence, there might be music that is most appropriate for one recovery strategy, but a different music type for an alternative strategy and the choice is likely dependent on the task completed and when the next activity is scheduled.

2.6 Mechanisms Underlying the Effects of Music in Sport and Exercise

The mechanisms underlying the effects of music in sport and exercise are poorly understood (Karageorghis & Priest, 2012a). The majority of research to date has focused on the consequences of music with the underlying mechanisms receiving insufficient attention. The following sections offer description of potential mechanisms that underpin the efficacy of music in sport and exercise contexts.

2.6.1 Emotional responses to music. Music can be a stimulus to induce emotion but also can expresses emotions that are perceived by a listener; the majority of studies have focused on the perception of emotion (Juslin, 2009). The notion that music can evoke emotions is an area of some controversy, and there remains debate as to what emotions music can induce, whether these are uniquely *musical emotions*, and the nature of the relationship between perceived and induced emotions (Juslin).

Emotion research rarely considers responses to music (Sloboda & Juslin, 2001). This lack of research examining emotional responses to music is surprising, and Sloboda and Juslin offered three possible reasons for this. First, mainstream psychology considers emotion with regard to its adaptive (evolutionary) value (e.g., Lazarus, 1991). The apparent difficultly of marrying emotional responses to music with Darwinian terms is likely to have been a significant factor in researchers' reluctance to examine emotional responses to music. This is in spite of Darwin himself recognising the peculiar role of music in our emotional lives (Juslin, 2009). Second, emotional responses to music are associated with great inter-individual variability and also change over time. Third, the often intrusive nature of closely observing an emotional response is likely to alter the effects that music may have.

Further reasons for the lack of music in emotion literature have also been offered: emotions induced by music are considered less important as researchers have failed to acknowledge the vital role that music plays in everyday life (Sloboda & O'Neill, 2001), emotional responses to art (including music) do not elicit the same emotional responses as "real life" events (Frijda, 1989). Therefore, mainstream theories of emotion may not generalise well to art forms such as music (North & Hargreaves, 2008). However, Sloboda and Juslin (2001) argued that the typical characteristics of emotion can be applied to music. They suggested that, just as emotions influence actions (e.g., fear will often lead to a person closing their eyes), emotions experienced through music inhibit or promote certain behaviour (e.g., excitable behaviour at music concerts).

Despite the overall lack of literature on musically-induced emotion, there is a body of literature demonstrating that music is used to regulate emotions and moods, and that positive emotions are the dominant response to music (e.g., Juslin, Liljeström, Västfjäll, Barradas, & Silva, 2008; North, Hargreaves, & Hargreaves, 2004; Sloboda, O'Neil, & Ivaldi, 2001). Juslin and Sloboda (2001) identified three approaches to conceptualising emotion that are outlined herein.

2.6.1.1 Conceptualisations of emotion. One of the most important decisions a researcher must take is whether to conceptualise emotions as distinct entities or as positioned along dimensions (Ekkekakis, 2013). The categorical approach to the conceptualisation of emotion postulates that people experience emotions as categories that are distinct from each other (North & Hargreaves, 2008). A fundamental aspect of this approach is the concept of basic, or primary, emotions. This approach dictates that there are a number of limited emotional categories from which all other emotional states are derived (Damasio, 2000; Ekman, 1992; Oatley, 1992). Each of these basic emotions are regarded as adaptive in terms of dealing with situations that require immediate actions (i.e., approach or avoid). The number of basic emotions is a topic of some debate (see Matsumoto & Ekman, 2009) but there appears to be some consensus on at least five basic emotions: happiness, sadness, anger, fear, and disgust (Sloboda & Juslin, 2001). Despite some contention regarding the number and exact constituents of basic emotions, there is a commonality among the different suggestions with the implication of an innate set of adaptive responses to the environment (Levenson, 1994).

Beyond classifications of basic emotions, there are emotions classified as complex. There are several differences between basic, or primary, emotions and complex, or secondary emotions. Basic emotions have distinct functions that contribute to survival, are evident in all cultures, are experienced as unique states, occur early in development, are associated with physiological changes, occur in other primates, and have distinct expressions (Ekman, 1992; Izard, 1977; Oatley, 1992; Panksepp, 1992 as cited in Sloboda & Juslin, 2001). Secondary emotions are much more recent in evolutionary terms and include cultural and individual influences. Secondary emotions are viewed as combinations of basic emotions (Plutchik, 1994), or the results of cognitive evaluation that occur with a basic emotion (Oatley, 1992). A central criticism of this approach is the assumption that an individual's emotional state falls within these pre-determined emotion categories, which is not likely to always be the case.

The prototypical approach proposes that emotions are arranged in a hierarchical order (Shaver, Schwartz, Kirson, & O'Connor, 1987). The central principle of this approach is that an emotion is determined by a resemblance to prototypical examples (e.g., worry is an example of fear). Shaver et al. proposed a hierarchy where the superordinate level states whether the emotion is positively or negative valenced. The middle level includes basic emotions, or prototypes, and the subordinate level are all the emotions within that category. The prototypical approach acknowledges that emotions cannot be defined by a distinct set of necessary and sufficient conditions (Sloboda & Juslin, 2001).

The conceptual alternative to the categorical approaches described above is a dimensional approach. The dimensional approach focuses on identifying emotions based on their location on dimensions such as valence, activity, and potency

(Sloboda & Juslin, 2001). Russell's (1980) circumplex model consists of a two-dimensional structure including valence and activation (see Figure 2.3); it is the most widely accepted conceptualisation of the dimensional approach to emotion. Within the circular structure, emotions that are positioned diametrically across from each other (e.g., happy and sad) differ maximally in terms of one or the other dimension (e.g., valence). The states that are diametrically opposite correlate inversely and are often considered bipolar. States that are close to each other (e.g., tranquil and calm) represent a similar mixture of valence and arousal. Russell (1980) described his conceptualisation by stating that "affective space lacks simple structure. Rather than clusters of synonyms falling near the axes, terms spread out more or less continually around the perimeter of the space" (p. 1167). This important distinction captures how his dimensional approach differs from the categorical approaches; the circumplex model does not predict a systematic clustering of states near the axes (Ekkekakis, 2013, p. 57).

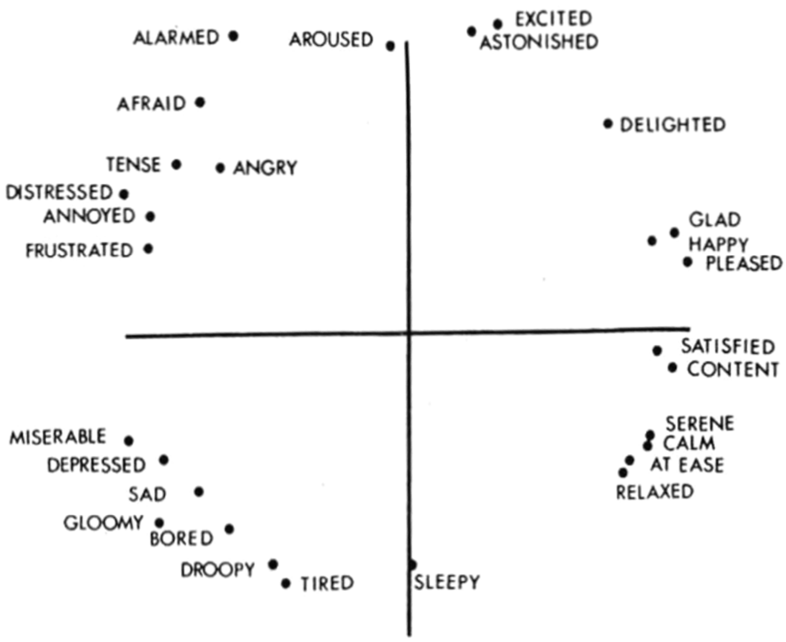

Figure 2.3. Russell's Circumplex Model of Affect (1980). Reprinted from "A Circumplex Model of Affect", by J. A Russell, 1980, Journal of Personality and Social Psychology, 39, p. 1168. Copyright 1980 by the American Psychological Association.

Schubert (2001) suggested that dimensional models may be particularly useful for capturing the continuous changes in emotional expression that occur during music. There have now been a number of studies that have used the circumplex model to capture the emotions evoked by music. North and Hargreaves (1997) examined the appropriateness of the circumplex model for music research. They played 32 tracks to participants and asked them to rate their liking for each track as well as how arousing they thought it was. A second group of participants were also played the 32 tracks and rated them according to eight different emotions. The results were "remarkably consistent with the circumplex model" (North & Hargreaves, 2008, p. 128) which demonstrated the appropriateness of the Circumplex Model for assessing affective responses to music.

The capacity of music to evoke emotions has not been subject to comprehensive scientific investigation. Juslin and Vastfjall (2008) argued that the study of musical emotions suffers from neglect to investigate the underlying mechanisms. Moreover, researchers have examined the emotional responses to music without regard for how they are evoked, or with an assumption that the emotional responses are based on a default mechanism of cognitive appraisal. It may be that emotions induced by music are not evoked through a process of appraisal in the conventional, evolutionary, sense.

2.6.1.2 Mechanisms for musically-induced emotions. Scherer and Zentner (2001) proposed that music generates emotion through two routes: central (concerning the central nervous system) and peripheral (based on direct effects of the peripheral nervous systems). Scherer and Zentner identified three underlying mechanisms by which music can evoke emotions via the central route. The first is appraisal wherein an individual evaluates a piece of music with respect to a number of criteria including the implications of the stimulus for the individual's needs, goals, and values. Karageorghis and Priest (2012a) suggested this appraisal mechanism is where an individual evaluates the personal significance of the music with regard to their wellbeing.

Scherer and Zentner (2001) suggested that memory is also a mechanism for emotion induction. A strong emotional reaction is stored in memory together with the experiential content, and this memory can be evoked spontaneously if triggered by the experiential content (i.e., a piece of music). They also claimed that the recall of such emotions can be as powerful as the initial experience. This notion of memory as a mechanism of emotion induction bears similarities to that of the hierarchical factors presented in the 1999 conceptual model by Karageorghis et al. (1999; see Figure 2.1). External factors such as associations have an important role to play in the effectiveness of music during exercise.

The final mechanism proposed by Scherer and Zentner (2001) is empathy, and this can be elicited through observation of another person being affected by an event. Appraisal and memory differ from empathy owing to the recollection of an event that happened specifically to the individual. The overlap of these mechanisms is not discussed by Scherer and Zentner, but it would be extremely challenging to isolate each of them. For instance, appraisal is likely to be based, in part, on prior experience whereby the individual would recall (memory) an event. Therefore, the central route of induction is likely to involve more than one of these routes. The description of emotion earlier (see Section 2.2.1) indicated that emotions are the sum of coordination and synchronisation of different systems. It appears more plausible that a central route involving more than one of the routes at any one time is the mechanism underlying an emotional response to a piece of music.

Peripheral routes were also described by Scherer and Zentner (2001). They acknowledged that these are much less established than the central routes, but offer an alternative for some types of music. Proprioceptive feedback is one such route and concerns the idea that an emotional response includes a number of components (a concept that is widely accepted) but that the whole system can be manipulated by affecting one of the components. Therefore, if music can influence one component of the system, peripheral mechanisms may explain the spread to other components that produces an emotion. Scherer and Zentner suggested that rhythm is a candidate for such an effect as a strong rhythm can have a noticeable effect on physical movements (nodding head in time with the beat) which often leads to the evocation of emotion.

2.6.2 Attentional processing. The dissociative effects of music during exercise are often cited as a significant factor underlying its efficacy (see Karageorghis & Priest, 2012a, 2012b). Dissociation refers to thoughts that serve to direct attention away from internal sensations and towards external stimuli (Morgan & Pollock, 1977). The term dissociation has been subject to some misinterpretation as the term is used by clinical psychologists to imply something negative or pathological (Masters & Ogles, 1998). As a result of this dual meaning, some researchers have referred to cognitive strategies as internal/external rather than association/dissociative, showing that the different cognitive strategies do not reflect cognitive processes but instead reflect different forms of attentional focus (Masters & Ogles). Internal attentional focus (i.e., association) concerns physical bodily sensations, whereas external attentional focus (i.e., dissociation) includes anything other than bodily sensations.

There are several models of attention that are relevant to the application of music in the sport and exercise domain. These models have evolved, not always within sport and exercise, and have been applied to a variety of contexts and activities. The following models are based on the premise that there is a limited capacity of the afferent nervous system (see Hernandez-Peon, Brust-Carmona, Penaloza-Rojas, & Bach-y-Rita, 1961; Moray, 1967).

2.6.2.1 Dual-task paradigm. The dual-task paradigm examines how a person manages two or more tasks simultaneously and how they divide their attention between the two. When the dual-task method is applied to sport and exercise, the physical activity (e.g., treadmill running) becomes the primary task. In the present programme of research, physical exercise is the primary task and other stimulus (e.g., music) is employed as a secondary task.

In research examining music and exercise, capacity interference is most relevant as the two tasks (e.g., treadmill exercise and listening to music) share no common perceptual or output processes. The music is often presented continuously throughout the physical activity and therefore the cumulative demands remain relatively constant throughout the task (e.g., Nethery, 2002; Tenenbaum et al., 2004). However, traditional measurement of the dual-task method is not appropriate for study designs including music. Music is rarely subject to objective measurement (i.e., statistical measurement of the structure of music; e.g., Simonton, 1986, 1987) with self-reporting (subjective) measures much more common (e.g., Karageorghis et al., 2011).

Enormous amounts of information (internal and external) constantly bombard the human senses. *Selective attention* is a term used to describe the process of preferentially selecting certain information for further processing at the cost of other information (Abernethy, 2001). A classic study by Cherry (1953) provided strong support for the theory of selective attention. In Cherry's study, participants were presented with two separate messages to each ear and were then required to verbally repeat the message presented to one of the ears. Results consistently indicated that participants were only able to process very little information from the message they were not required to verbally repeat; suggesting the participant could selectively process only the information relevant to the task at hand. However, some elements (a change from male to female voice, and the use of a high frequency tone) of the message that participants were not required to listen to were often detected, suggesting preferential processing of this kind of information. Perhaps music, or certain aspects of music, possesses elements that people preferentially select.

2.6.2.2 Parallel processing. The parallel processing model has been used extensively in the sport psychology literature and a major proponent of this was Rejeski (1985; see Figure 2.4) whose model followed directly from Leventhal and Everhart's (1979) parallel processing model relating to pain. Leventhal and Everhart offered a parallel processing model (parallel processing of information, pain, and distress) that arranged informational and emotional components in parallel rather than in sequence. Interest in the role of dissociation as a method of alleviating the discomfort associated with exercise-induced fatigue is not a recent development (e.g., Benson, Dryer, & Hartley, 1978).

Despite studies examining dissociation during exercise, there was a lack of theoretical reasoning as to how and why it was an effective coping mechanism. Rejeski (1985) hypothesised that dissociative strategies provide relief from fatigue by occupying limited channel capacity that is essential to bringing perception into focal awareness. This assertion seems to be partly based on Pennebaker and

Lightner's (1980) findings that during exercise, external cues do compete with internal cues. Pennebaker and Lightner suggested that processing of internal sensations was restricted for participants who focused on external cues to a higher degree during a cross-country trial. Rejeski also suggested that "there is a point in the physical stress of exercise at which sensory cues, due to their strength, dominate perception. Under such conditions, it seems unreasonable to expect mediation by psychological factors." (p. 372). This assertion was later echoed by Tenenbaum (2001) in his model (see Section 2.6.2.3).

Figure 2.4 shows Rejeski's parallel processing model (1985). Rejeski describes how perception is an active process and "considerable weight is given to the preconscious elaboration of sensations." (p. 373). The model distinguishes between perception (preconscious) and focal awareness (conscious) wherein perception is all processed information that can be attended to, but focal awareness is that which is attended to.

2.6.2.3 Auditory and visual processing. According to Rejeski's model (1985), physical work is the stimulus which generates sensory cues that are pre-consciously processed. During physical work, the strength of internally-generated cues (i.e., fatigue-related cues) increases with the level of physical work. However, it is not only internal bodily changes that provide cues; the external environment continues to stimulate the senses. Extant neuroscientific evidence shows that visual cues dominate auditory cues in determining behavioural response (e.g., Colavita, 1974; Koppen, Levitan, & Spence, 2009). In line with Rejeski's model (1985) and the notion of limited attentional capacity, it is likely that visual stimuli are more effective when competing with internal cues than auditory stimuli.

Physical work is unlikely to be conducted in the absence of other sensory information (e.g., a blindfold or noise-cancelling headphones); therefore all the senses will continue to receive cues during physical work. If there is an increasing amount of internal, fatigue related information received during physical work, there is less likelihood that cues received from external senses (i.e., optic, auditory, tactile, olfactory, and gustatory) will make it through from preconscious to conscious processing. External cues must compete with the increasing strength/amount of the internal sensations for conscious awareness, and it is logical to suggest that visual stimuli rather than auditory stimuli would be more successful in this competition given the preference for visual stimuli when presented bimodally with other senses (Hartcher-O'Brien, Gallace, Krings, Koppen, & Spence, 2008; Koppen & Spence, 2007). It may be that visual stimuli have greater capacity to capture the attention of an individual during exercise and therefore distract from the internal fatigue-related cues. In light of this, experimental designs comparing the efficacy of visual and auditory stimuli during exercise appear to be warranted.

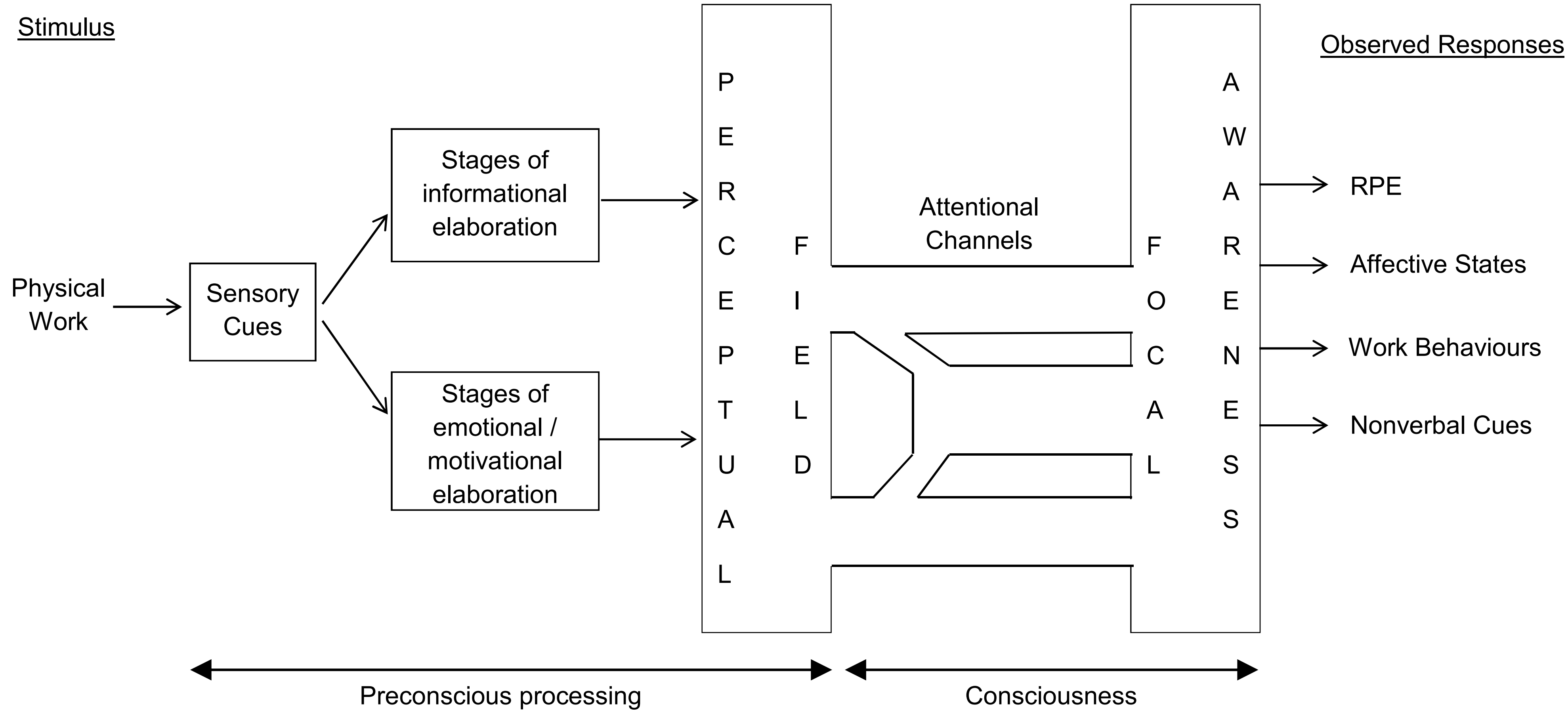

Figure 2.4. Rejeski's Parallel-processing model (1985). Reprinted from "Perceived Exertion: An Active or Passive Process", by W. J. Rejeski, 1985, *Journal of Sport Psychology*, *7*, p. 374. Copyright 1985 by Taylor & Francis Ltd.

2.6.2.4 Tenenbaum's social-cognitive model of attention (2001).

Tenenbaum (2001) presented a model that incorporated attentional mode (internal/external), perceived exertion, and exercise intensity (see Figure 2.5). Tenenbaum's model shares a number of characteristics with Rejeski's (1985); specifically the inclusion of perceived exertion and how these perceptions are determined by intensity level. However, Tenenbaum utilised research conducted after the construction of Rejeski's model to provide a more comprehensive framework that included a greater range of determinants (e.g., demographics and environmental conditions). A significant aspect of Tenenbaum's model is the direction of attention (associative/internal or dissociative/external) that an individual will adopt during high intensity-exercise.

Tenenbaum's model (2001) dictates that at low intensity exercise, and subsequently low levels of perceived exertion, the exerciser maintains the capacity to shift between an associative or dissociative focus. As such, during exercise of low intensity, the exerciser may choose to shift between attending to bodily sensations (e.g., sweating and heavy breathing) and diverting away from these to external stimuli (e.g., music). However, as the exercise intensity increases, and perceived exertion increases, attentional focus becomes predominantly internal and cognitive strategies become gradually less effective at influencing perceived exertion. During high intensity exercise, when perceived exertion is high, it is much harder to voluntarily shift attention away from the bodily sensations. A further aspect of the model relates to the undifferentiated fatigue experienced at high intensities, as opposed to discrete fatigue at low intensities, and this superordinate level of fatigue means the shift away from fatigue related sensations is more difficult. The practical application of the model can lead to difficulties as there are no specific descriptions of what constitutes low, moderate, and high exercise intensity exercise (i.e., $\%VO_{2\,max}$). However, Tenenbaum et al. (2004) suggested that exercise intensities in excess of $90\%VO_{2\,max}$ were beyond the distraction capabilities of external stimulus (music).

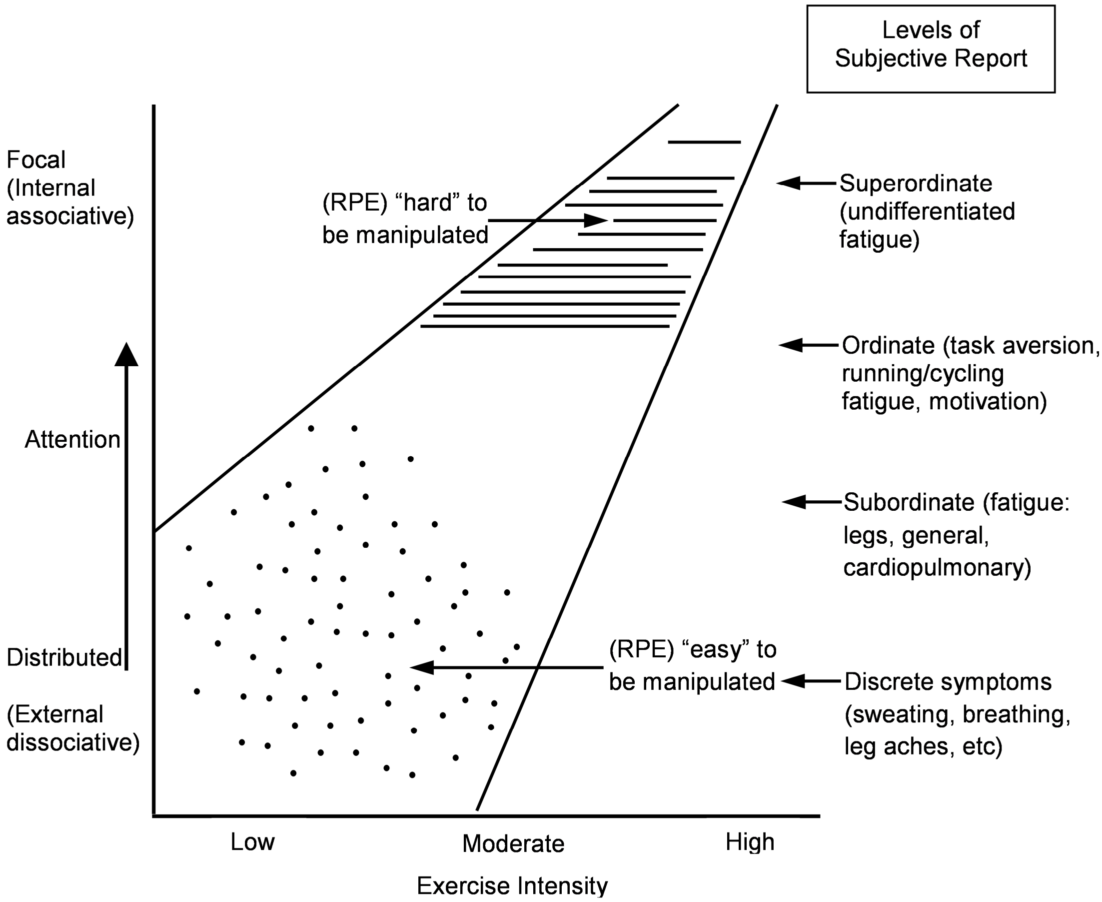

Figure 2.5. Tenenbaum's Social-cognitive Model of Attention (2001). Reprinted from "A Social-Cognitive Perspective to Perceived Exertion and Exertion Tolerance" (p. 813), by G. Tenenbaum in Handbook of Sport Psychology (2nd ed.), R. N. Singer, H. A Hausenblas, and C. M. Janelle (Eds), 2001, New York, NY: Wiley

2.6.2.5 The dual-mode model of affective responses to exercise of varying intensities. Ekkekakis (2003) presented a model that sought to advance the earlier work of Rejeski (1985) and Tenenbaum (2001). The earlier models represented a significant theoretical advance in their depiction of a continuous competition between internal and external cues, the active channelling of sensory input, and the intensity dependent shift in the contributions of psychological factors (including attentional focus) and physiological cues. Ekkekakis cited these theoretical developments as the foundation for his Dual-mode Model, and sought to advance the models by identifying specific physiological markers as key turn points in the transition from cognitive (external) to interoceptive (internal) mode. It was postulated that ventilatory threshold (VT) is the key turn point for affective responses as it is here that physiological adjustments take place that drastically alter the internal environment (e.g., lactic acidosis, accelerated breakdown of creatine phosphate, inhibition of lipolysis). The capacity of music to influence affect during exercise has been shown in a number of studies (e.g., Elliott, 2007; Karageorghis et al., 2009) and Ekkekakis's work presents a noteworthy platform with which to examine the influence of music on affective valence across exercise intensities.

Ekkekakis's (2003) model was based on a line of research that investigated the relationship between affective valence and various physiological measures. Ekkekakis, Hall, and Petruzzello (1999) conducted the first study to assess physiological parameters and a cognitive correlates of affective response to exercise (self-efficacy). This study examined participants' affective responses during a maximal exercise test and it was found that exercise performed at an intensity below gas exchange threshold, but not below other physiological variables (respiratory exchange ratio and percentage of peak heart rate), accounted for a significant proportion of variance in affective valence. A similar study (Hall, Ekkekakis, & Petruzzello, 2002) assessed changes in the self-efficacy of participants running on a treadmill at speeds that equated to exercise intensities below, at, and above VT. It was found that self-efficacy accounted for almost two-thirds of variance during the below VT condition, almost all the variance while exercising at VT, but less than half of the variance during exercise above VT. A general limitation of these studies concerns the range of exercise intensities examined. Exercise of very low intensity (e.g., walking) would have allowed for a greater exploration of affective responses over a wider range exercise intensities and provided greater understanding of the pattern of affective responses.

Acevedo, Kramer, Haltom, and Tryniecki (2003) showed that affective valence was not related to physiological variables (heart rate and ventilation) below or at the onset of blood lactate accumulation. However, affective valence was significantly related in a negative direction to heart rate and ventilation at exercise intensities beyond the onset of blood lactate accumulation. Ekkekakis (2003) suggested that affective valence is strongly related to physiological indices once exercise intensity shifts from predominantly aerobic to predominantly anaerobic metabolism.

The dual-mode model is based on a series of assumptions highlighted by Ekkekakis and colleagues (Ekkekakis, 2003; Ekkekakis, Hall, & Petruzzello, 2005): physical activity has been an essential component of human evolution; affective responses are manifestations of evolved psychological mechanisms; affective responses depend on a hierarchical system from evolutionary primitive pathways at the bottom through to evolutionary recent cortical pathways at the top; primitive pathways show less interindividual variability, whereas more recent pathways show larger variability shaped by individual development. Based on these assumptions, the dual-mode model (Ekkekakis, 2003) posits that affective responses during exercise results from a continuous interplay between cognitive processes in the frontal cortex and interoceptive cues from a variety of receptors. The prominence of these two factors shifts as a function of exercise intensity; specifically, cognitive processes are dominant at intensities below VT, there is interindividual variability at intensities proximal to VT, and interoceptive cues become prominent when intensity exceeds VT and approaches maximal capacity (see Figure 2.6). The respiratory compensation point (RCP) marks the beginning of severe exercise intensities and at this point there is a predominant response of displeasure.

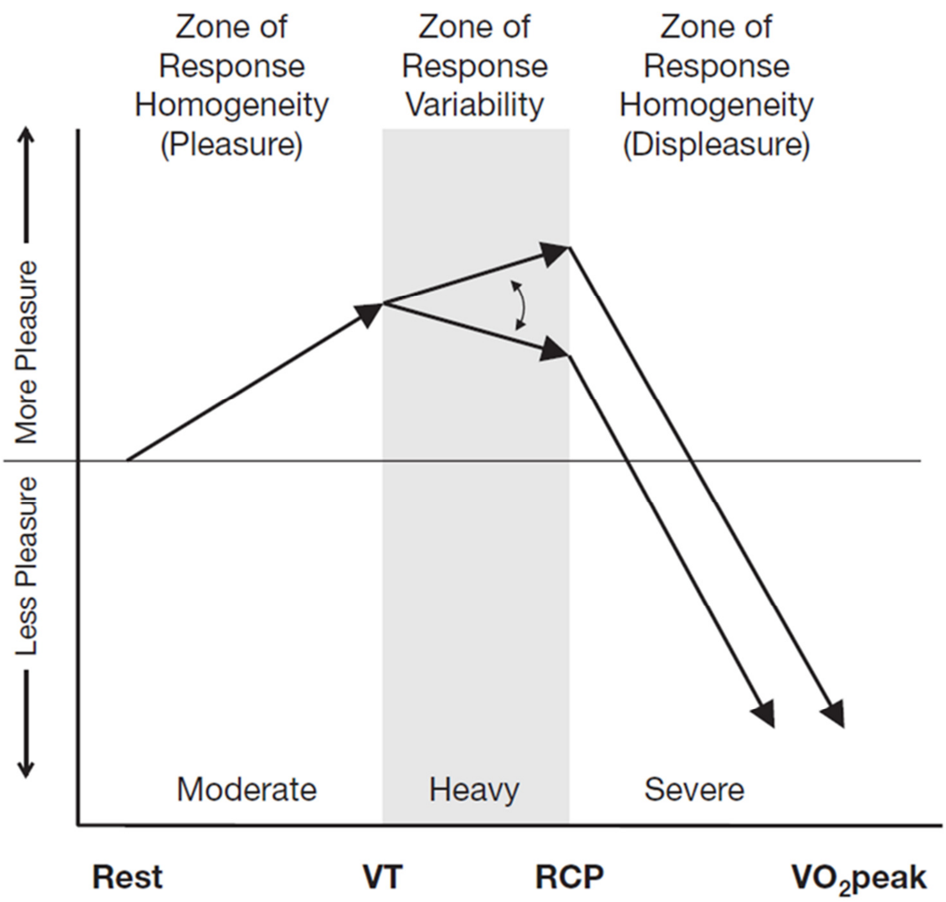

Figure 2.6. Ekkekakis' Dual-Mode Model of Affective Responses to Exercise of Varying Intensities (2003). Reprinted from http://www.public.iastate.edu/~ekkekaki/dual_mode_theory.pdf

Overall, these models (Ekkekakis, 2003; Rejeski, 1985; Tenenbaum, 2001) suggest that cognitions are able to be manipulated at exercise of low-to-moderate intensities (below VT), but it becomes increasingly difficult to influence cognitions as exercise intensity increases. This presents a significant challenge for the use of music in exercise settings as the models suggest that external stimuli cannot capture the attention of an individual during moderate-to-high intensity exercise. If music could be shown to influence cognitions during exercise of moderate-to-high intensity, it would demonstrate the power of music to influence cognitions and emotions that would positively shape the exercise experience.

2.6.2.6 Association/Dissociation. Association and dissociation describe cognitive strategies that show the extent to which an athlete focuses their attention on internal feedback (Hutchinson & Tenenbaum, 2007). Morgan and Pollock (1977) first highlighted a distinction between these two categories of attentional focus, and this idea has become a dominant concept in the link between attentional focus and physical exertion. Association is regarded as an internal attentional style in which athletes monitor physiological sensations. Dissociation concerns an external focus on environmental data (Pennebaker & Lightner, 1980). It has been posited that music can be effective as an aid to dissociation (Terry & Karageorghis, 2006).

Following Morgan and Pollock's (1977) paper, a number of studies were conducted in the 1980s that sought to examine the influence of attentional focus on running performance. Saintsing, Richman, and Bergey (1988) suggested that an associative focus facilitated improvement in a running task, but other research contrasted this finding and suggested it was external focus which would improve performance (e.g., Padget & Hill, 1989; Pennebaker & Lightner, 1980). Further, studies have found that attentional focus, regardless of type (association or dissociation), did not improve performance (e.g. Fillingham & Fine, 1986; Wrisberg, Franks, Birdwell & High, 1988). Several studies have explored the correlation between attentional focus and running performance and a consistent finding was that association is related to faster running times and dissociation is related to slower running times (e.g., Heffner, 2005; Schomer, 1986; Silva & Applebaum, 1989).

Papers such as those by Silva and Applebaum (1989) and Schomer (1986) found that the most competitively successful marathon runners used a combination of associative and dissociative attentional strategies. Although both strategies were employed, an increased running pace was accompanied by a predominately associative strategy. Less successful marathon runners almost exclusively used a dissociative strategy with the aim of ignoring physiological/biological feedback to help deal with the boredom and fatigue of marathon running. A significant limitation to this line of research is that causation cannot be determined, that is to say, it is not clear if an associative strategy leads to faster running times or faster running times lead to association.

Stevinson and Biddle (1998) proposed a two-dimensional model that sought to advance the dichotomous approach to attentional focus. Their model included the direction of attention (internal or external) and task relevance (relevant or irrelevant). Task-relevant thoughts involving an internal focus were classified as internal association (e.g., muscle soreness), whereas task-relevant thoughts with an external focus were classified as external association (e.g., distance markers). Task-irrelevant thoughts with an internal focus were categorised as internal dissociation (e.g., daydreams), and task-irrelevant thoughts with an external focus as external dissociation (e.g., scenery). However, this two-dimensional approach might not always be appropriate and seems particularly relevant in a context where any of the four categories can be freely adopted by an individual, but during experimental testing in a controlled environment such as a laboratory the model may not be relevant. In such controlled environments, it may not be possible for an individual to focus on external task-relevant information (e.g., scenery) owing to such stimuli not being available to the participant.

Hutchinson and Tenenbaum (2007) acknowledged the more comprehensive classification of attentional focus offered by Stevinson and Biddle's (1998) model, but felt that the closed environment in which their study was conducted (a laboratory) did not lend itself to the directions of attention proposed by Stevinson and Biddle. Hutchinson and Tenenbaum employed the dichotomous classification of attentional focus in their closed environment study. The premise that a dichotomous approach is more appropriate in a closed environment received support from Stanley, Pargman, and Tenenbaum (2007).

Although the relationship between attentional style and key performance measures has been shown empirically, there is a lack of a unifying theoretical framework to account for variation in attentional focus (Heffner, 2005). Tammen (1996) suggested that association/dissociation represent two contrasting approaches to coping with discomfort during long-duration running. This suggestion runs counter to an earlier claim by Masters and Lambert (1989) who noted that extant data seemed to refute the suggestion that dissociation is used as a strategy to cope with pain during running. Masters and Lambert's study of marathon runners found that participants were more likely to associate during competition and more likely to dissociate during training. It is likely that competitive runs will be of greater intensity than training runs and therefore more likely to induce high levels of pain; therefore the findings of Masters and Lambert run counter to Tammen's suggestion.

Masters and Ogles (1998) surmised that the findings indicating that runner's prefer association during races and dissociation during training are "probably two sides of the same coin" (p. 263) given that training runs are conducted at a slower pace than race pace. Research has shown that during a slower pace, a runner may be more able to engage in mental activity (Masters & Lambert, 1989; Sacks, Milvey, Perry, & Sherman, 1981) and this supports theoretical models (Ekkekakis, 2003; Rejeski, 1985; Tenenbaum, 2001).

Evidence has continued to emerge in support of the models. Hutchinson and Tenenbaum (2007) sought to test the exercise intensity-attentional focus model by examining attentional strategies during two physically demanding tests. Their findings offered support for Tenenbaum's (2001) model owing to individuals reporting a predominantly associative focus during high-intensity tasks of treadmill running and hand-grip dynamometry. Further support of Tenenbaum's model was reported in a study examining high-school rowers. Attentional focus shifted from dissociation to association as workload increased from 30% of maximal workload through to 70% (Connolly & Tenenbaum, 2010).

Although studies have sought to examine the effects of exercise intensity on attentional focus, there have been none to date that have examined whether music can moderate the relationship between exercise intensity and attentional focus. The switching from predominantly dissociative to predominantly associative focus, which accompanies a shift towards more negative affective valence as exercise intensity increases, is a consistent finding (e.g., Baden, Warwick-Evans, & Lakomy, 2004; Masters, 1992; Welch, Hulley, Ferguson, & Beauchamp, 2007). An interesting extension would be to explore whether music could delay this shift and extend the range of exercise intensities that are associated with positive affect.

2.6.3 Motivation as a mechanism underlying the effects of music during exercise. Research exploring music and exercise has often focused on the capacity of music to motivate an individual. The models of Karageorghis and colleagues (1999;

2006) focused on *motivational* music and this intuitively appealing benefit of music makes the use of it in an exercise context even more salient. Addressing the lack of motivation to exercise is integral to overcoming the physical inactivity epidemic. Motivation can be examined from both trait and state perspectives and perhaps music can positively influence both of these types of motivation.

Human motivation is a concept that has been of an area of documented interest since antiquity. In his treatise, On The Soul, Aristotle declared:

> *That which moves therefore is a single faculty and the faculty of appetite….it is the object of appetite which originates movement, this object may be either the real or the apparent good….in the case of sensation it pronounces the object to be pleasant or painful, in this case it avoids or pursues and so generally in cases of action.* (Aristotle, trans. 2000).

The notion of pleasure-pain underpinning motivation has long been acknowledged and is embedded in disciplines across the psychology literature. Freud acknowledged the principle of pleasure as a primary mechanism of motivation and suggested that the human organism is driven to seek pleasurable experiences and avoid pain. Berlyne (1971) interpreted Freud's psychoanalytic work with a view to its application in experimental aesthetics, and suggested that from a psychoanalytic perspective "art is interpreted as a vehicle of disguised expression for unfulfilled wishes, which to a large extent are unconscious." (p. 13). Berlyne went on to suggest that psychoanalysis has a great deal to say about the content of aesthetics (e.g., music) but has little to say about the formal or structural aspects of art. Moreover, that psychoanalytic theory cannot help to explain why certain aesthetic structures or patterns are much more conducive to appreciation than others.

Contemporary research has presented a vast array of motivational theories but few have been examined in a music and exercise context. Barwood et al. (2009) sought to apply Bandura's theory of self-efficacy (1977, 1986) when designing a video intervention that would be played to participants during exercise. They suggested that video montages including still images and video footage of high-profile British sporting success (the research was completed at a British university) would "stimulate the vicarious experience component of self-efficacy" (p. 437). However, they did not measure self-efficacy at any stage of the study and were only able to make the assumption in their discussion that the video montage "boosted self-efficacy" (p. 438). If measures of self-efficacy had been included in the study, it would have represented a step forward in the literature regarding the application of motivational theories in the context of video and exercise. Moreover, given the links between self-efficacy and affect expounded by Ekkekakis et al. (1999), the measurement of self-efficacy would have represented a fillip for the research area.

Bandura (1986, 1997) suggested four ways in which to enhance, or diminish, self-efficacy. Of these, verbal and social persuasion, and imitation and modelling appear to be ways in which music could enhance self-efficacy in an exercise context. A song with positive lyrical affirmations can act as verbal persuasion to continue with an exercise session even though sensations of fatigue might be almost overwhelming. For example, a song by The Hours entitled *Ali In The Jungle* contains the lyrics "It's, not, how you start, it's how you finish….Everybody gets knocked down, how quick are you gonna get up?" which could represent verbal persuasion to respond to the sensation of fatigue and continue the session. Imitation and modelling may be related to the *Association* component of Karageorghis et al's (1999) model. A well-known example of this is the motion picture *Rocky IV* where the protagonist

(Rocky “The Italian Stallion” Balboa) responds to a considerable beating by his opponent (Ivan Drago) in emphatic fashion to defeat his opponent alongside a memorable soundtrack. Upon hearing the music that accompanies the *Rocky* film series, individuals may associate the music with the exploits of Rocky Balboa and seek to imitate his triumph in the face of adversity.

2.6.3.1 Self-determination theory. A theory of motivation used prolifically in sport and exercise literature is self-determination theory (SDT; Deci & Ryan, 1985). In a review of motivation theories most relevant to exercise and physical activity, Biddle and Mutrie (2008) concluded that Cognitive Evaluation Theory and SDT are viable and important theories for the study of motivational processes in physical activity, and SDT in particular is likely to enhance the understanding of motivation in the future.

Figure 2.7 provides a diagrammatic representation of self-determination theory (SDT; Deci & Ryan, 1985). A principle of SDT is that different types of motivation are distinguishable by the reasons or goals that drive them. The most notable distinction is between intrinsic and extrinsic motivation. Intrinsic motivation relates to the purpose of performing behaviour for the pleasure and satisfaction of the activity. Contrastingly, extrinsic motivation concerns the performance of a behaviour for contingent outcomes that are outside the activity itself (e.g., rewards or praise; Buckworth, Lee, Regan, Schneider, & DiClemente, 2007).

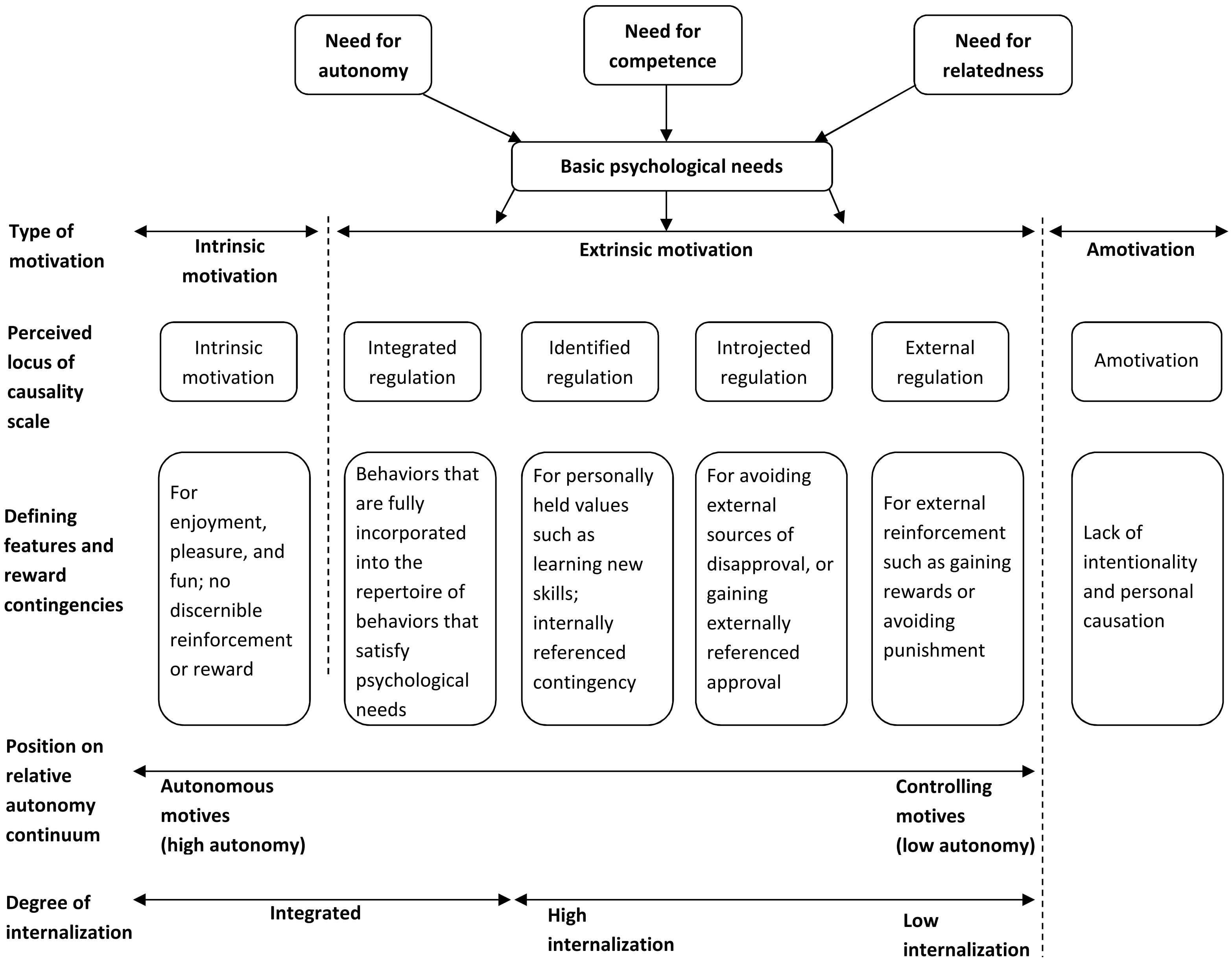

Figure 2.7. Illustration of self-determination theory. Adapted from “*Intrinsic Motivation and Self-Determination in Exercise and Sport”* (p. 8) by M. S. Hagger, & N. L. D Chatzisarantis (Eds.), 2007, Champaign: IL, Human Kinetics.

A key facet of SDT is the different types of extrinsic motivation that vary according to the level of autonomy. *External Regulation* is a highly controlled form of extrinsic motivation and an individual would expect to be rewarded, or avoid punishment, if they achieved the goal. *Introjected Regulation* can also be considered a controlling form of motivation whereby an individual is controlled by pressures and contingent rewards (Ryan & Deci, 2007). This type of motivation is relatively more autonomous than external regulation and the individual would control themselves with internal rewards or punishments (Ryan, 1982). An even more autonomous form of extrinsic motivation is *Identified Regulation*; this is characterised by participation in an activity because an individual recognises and identifies its purpose and value. At the most autonomous end of the extrinsic motivation is *Integrated Regulation*. This refers to behaviours that have been integrated into an individual's goals, and these satisfy the underlying psychological needs (Hagger & Chatzisarantis, 2007)

There are numerous benefits for individuals who are intrinsically motivated compared to those who are externally controlled. Intrinsically motivated individuals exhibit greater interest, excitement, and confidence (Deci & Ryan, 2000). Self-esteem (MacIntyre & Potter, 2013) and wellbeing (Gagne, Ryan, & Bargmann, 2003) are also positive manifestations of intrinsic motivation. Deci and Ryan state that conditions supportive of autonomy and competence reliably contribute to the development of intrinsic motivation. Autonomy has been defined "as the need to feel like the 'origin' of the behaviour and to experience choice and freedom in action" (Chatzisarantis, Biddle, & Meek, 1997, p. 345). Autonomy can be satisfied when behaviour concurs with personal inclinations but cannot be satisfied if there is a mismatch between behaviour and personal inclinations.

There is some preliminary evidence to suggest that SDT may be relevant in music and exercise contexts (Dwyer, 1995). Dwyer created two participant groups (Choice or No choice) among female adults attending exercise-to-music sessions. Participants in the *Choice* group were asked about their musical preferences and led to believe that the music played during the exercise-to-music sessions represented their previous choices. Participants in the *No choice* group listened to the same music but were not asked about their musical preferences. Results showed that participants in the *Choice* group reported greater intrinsic motivation when compared to participants in the *No Choice* group.

The use of self-selected music during exercise may give a person a sense of choice, perhaps more so than is experienced solely through participating in an exercise activity. Certain exercises (e.g., outdoor running and cycling) can inherently give an individual a sense of choice (autonomy) as they can choose where to exercise, the duration, and the intensity of the exercise. Previous studies (e.g., Elliott et al., 2004; Karageorghis et al., 2008) have demonstrated that music enhances enjoyment during exercise compared to exercise without music. However, these studies have sought to employ highly internally valid experimental designs and were conducted in a laboratory. Therefore, it is not known whether music can enhance a sense of autonomy in conditions where participants already have a strong sense of choice within their exercise session (i.e., outdoor running and cycling). Deci and Ryan (1985) revealed that choice, acknowledgement of feelings, and opportunities for self-direction were found to enhance intrinsic motivation because they allow for greater feelings of autonomy. It may be that if an individual were to add music to their exercise session, it might enhance their sense of autonomy (as they could select whichever tracks they wished to listen to) along with enhancing their enjoyment.

Moreover, it has been shown that music reflects the feelings of a listener (North & Hargreaves, 2008). As such music could also present a way for a person to acknowledge and express their feelings, which Deci and Ryan (2000) suggested was imperative to the enhancement of intrinsic motivation.

Schneider and Kwan (2013) examined whether affective responses and psychological need satisfaction independently predicted intrinsic motivation to exercise among adolescents. They found a significant positive association between acute levels of affect (measured immediately after a moderate- and high-intensity exercise session) and intrinsic motivation for exercise. This offers some evidence that increases in affective valence as a consequence of exercise can lead to enhanced intrinsic motivation. Studies within the music and exercise literature have indicated that music can enhance levels of affect beyond that recorded in conditions without music (e.g., Elliott et al., 2004; Hutchinson et al., 2011). The significant influences of music on affect, and the links between affect and intrinsic motivation, raise the possibility that music interventions during exercise might enhance intrinsic motivation.

2.6.3.2 Vallerand's (1997) hierarchical model of intrinsic and extrinsic motivation. Vallerand (1997) proposed a hierarchical model of intrinsic and extrinsic motivation (HMIEM) that sought to explain motivational determinants and consequences across three levels of generality (global, contextual, and situational; see Figure 2.8). This model includes the key tenets of SDT and represents a prominent approach towards motivation in a sport and exercise context and provides testable hypotheses on which a wide range of sport and exercise research has been predicated (Vallerand). Vallerand suggested that intrinsic motivation, extrinsic motivation, and amotivation exist at each of the three levels of generality (see

Vallerand, 2007, for a review). It is at the contextual and situational levels that sport and exercise research has been conducted. A characteristic of Vallerand's model is the top-down and bottom up relationships between proximal levels of generality (i.e., contextual motivation influences both global and situational motivation). The top-down relationship between contextual motivation and situational relationships have received some attention in the sport and exercise literature (e.g., Blanchard, Mask, Vallerand, Sablonniere, & Provencher, 2007; Ntoumanis & Blaymires, 2003), but this relationship has yet to be examined using music and exercise. Ntoumanis and Blaymires found that contextual motivation for physical activity predicted situational motivation for physical activity.

Regarding contextual-level motivation towards exercise, music is a ubiquitous factor in many people's exercise experience. Therefore, music may be contributing to motivation at a contextual level for exercise and, in line with the tenets of HMIEM, global and situational levels of motivation. Although the tenets of HMIEM state that one level of generality relates to another proximal level, the links between motivation at a contextual level and a behavioural consequence at a global level would prove challenging to establish owing to the difficulty in isolating the effects of music and exercise in larger behavioural changes. However, the situational level consequences following a music and exercise session could be more accurately related to contextual level motivation for exercise and would provide some evidence for the links between the levels of generality in this domain. This approach of examining contextual level motivation and situational level consequences has only been undertaken in a small number of studies (e.g., Ntoumanis & Blaymires, 2003) and was identified as an area of future research by Vallerand (2007).

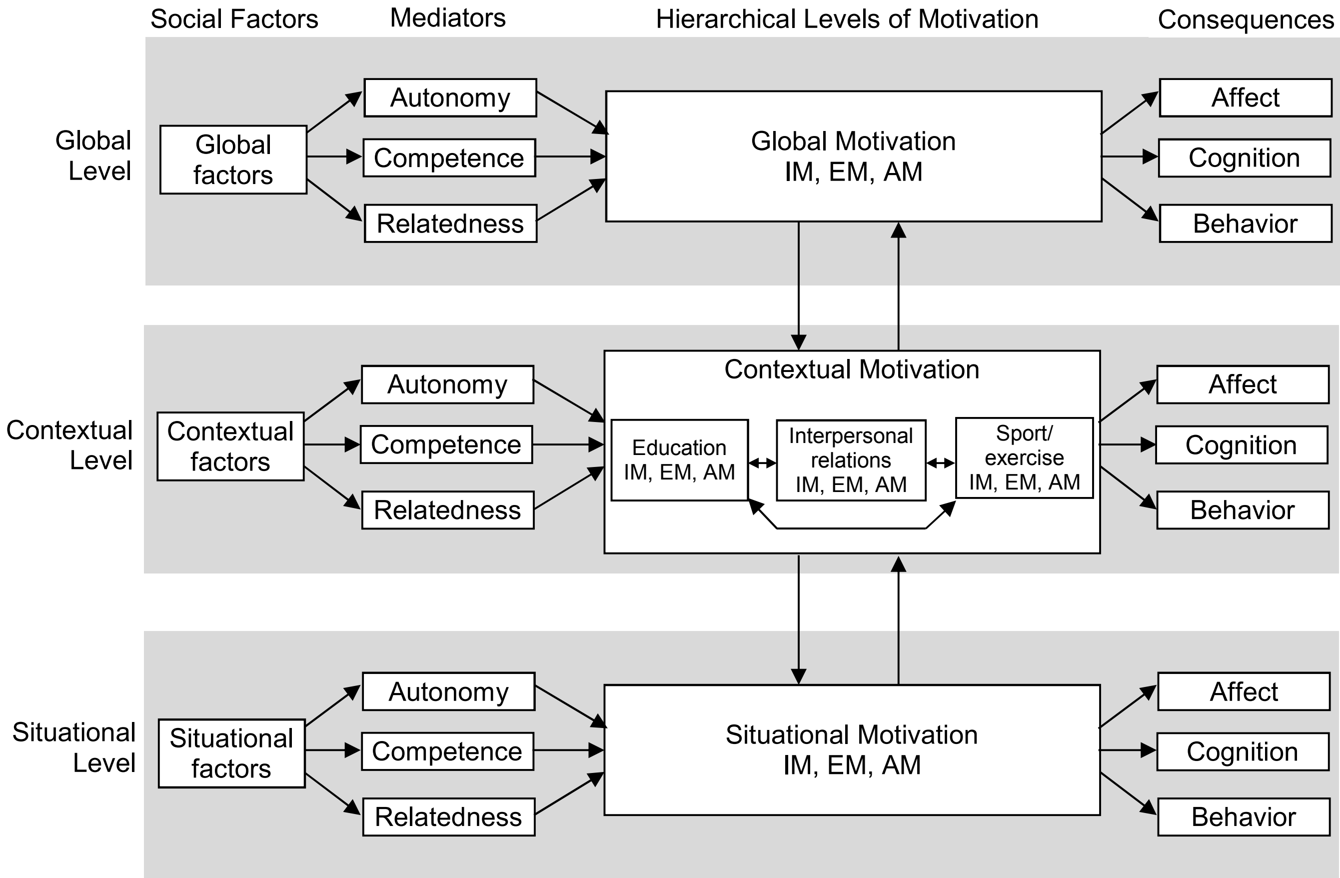

Figure 2.8. Vallerand's hierarchical model of intrinsic and extrinsic motivation (1997). *Note:* IM = Intrinsic Motivation; EM = Extrinsic Motivation; AM = Amotivation. Adapted from "Intrinsic and Extrinsic Motivation in Sport and Exercise: A Review Using the Hierarchical Model of Intrinsic and Extrinsic Motivation" (p. 391), by R. J. Vallerand and F. L Rousseau, in *Handbook of Sport Psychology* (2nd ed.), R. N. Singer, H. A Hausenblas, and C. M. Janelle (Eds), 2001, New York, NY: Wiley.

2.6.4 Exercise heart rate and preference for music tempo. The 1999 conceptual model by Karageorghis et al. proposed that the internal components of music are of greater importance to its motivational qualities than the external factors. Of these internal musical components, rhythm response, and more specifically tempo, is considered the strongest determinant of music preference. The assertion that tempo is of particular importance is supported by an extensive evidence base (e.g., Gundlach, 1935; Hevner, 1937; Juslin, 1997; Rigg, 1964; Scherer & Oshinsky, 1977). Fast tempo is often associated with various expressions of excitement, happiness/pleasantness, potency, surprise, anger, and fear; whereas slow tempo may be associated with calmness, solemnity, sadness, tenderness, boredom, and disgust (Juslin & Sloboda, 2001).

North and Hargreaves (2008) asserted a link between the stimulative properties of a piece of music (especially tempo and volume) and its function in different listening situations. Their assertion was based on Berlyne’s (1971) theory of experimental aesthetics and stated that the more arousal a situation required, the more preference would be afforded to stimulative music. Berlyne hypothesised that preference for different tempi should be affected by the physiological arousal of the listener and the context in which the music is heard. Accordingly, there might be a stronger preference for fast tempo music during physical activity.

A body of work has addressed the relationship between working heart rate, usually during an exercise task, and preference for music tempo (e.g., Karageorghis et al., 2006a; Karageorghis et al., 2008; Karageorghis et al., 2011). Such work stems from the notion that music tempo should be allied to expected heart rate (see Gfeller, 1988). Also, work in the field of experimental aesthetics (e.g., Berlyne, 1971) indicates that the *arousal potential* of stimuli determines preference. By arousal potential, Berlyne was referring to the amount of activity that stimuli induce in areas of the brain such as the reticular activating system. Stimuli that have a moderate degree of arousal potential are liked most and the degree of liking decreases towards the extremes of arousal potential; a classic inverted-U relationship.

Iwanaga (1995a) sought to test the hypothesis that people prefer auditory stimuli with tempi within the range of normal heart-rate patterning during everyday activity (e.g., 70–100 bpm). Participants searched for their favourite tempo through a process of self-regulation wherein they adjusted the frequency of a 440 Hz pure tone. As predicted, the preferred tempi were close to heart rate. Iwanaga (1995b) then sought to extend this line of investigation to a musical stimulus by examining the hypothesised linear relationship between heart rate and music tempi preferences. As in the previous study, there was a significant positive relationship between heart rate and preferred tempo. Iwanaga's (1995a, 1995b) work received some criticism from LeBlanc (1995) who suggested that the methodological approach lacked external validity.

LeBlanc's (1995) main criticism was that listeners are seldom able to alter the tempo of a musical piece to which they are listening. LeBlanc argued that in traditional music research (e.g., LeBlanc, Colman, McCrary, Sherrill, & Malin, 1988; LeBlanc & McCrary, 1983), where participants did not manually manipulate tempo, it was evident that listeners preferred tempi slightly higher than their heart rate if at rest, or when performing normal activity (i.e., not vigorous physical activity). LeBlanc also highlighted that younger listeners generally prefer higher tempi (LeBlanc, 1982; LeBlanc et al., 1988), a finding that was later supported by Priest, Karageorghis, and Sharp (2004).

LeBlanc (1995) suggested that Iwanaga's findings could be validated by having the same group of participants select their preferred tempi at varying work intensities. If these participants preferred tempi close to their heart rates in a range of conditions at different work intensities, it would offer support to Iwanaga's (1995a, 1995b) hypothesis. This suggestion formed a central premise of a study conducted by Karageorghis et al. (2006a) that examined the heart rate-music tempo preference relationship in an exercise context.

Participants in the Karageorghis et al. (2006a) study reported their preference for slow (80 bpm), medium (120 bpm), and fast (140 bpm) tempo music selections in each of three treadmill walking conditions at 40%, 60%, and 75% of maximal heart rate reserve (maxHRR). A significant and large main effect for music tempo was found, wherein a general preference for fast and medium tempo music over slow music was evident (η_p^2 = .78). A moderate Exercise Intensity x Tempo interaction effect was also observed (η_p^2 = .09), with participants reporting a preference for either fast- or medium-tempo music during low and moderate exercise intensities, but only fast-tempo music during high intensity exercise. Interestingly, the highest preference scores were recorded while participants listened to fast-tempo music at high work intensity (75% maxHRR).

Karageorghis et al. (2008) conducted a follow-up study to extend this line of investigation from listening to single music excerpts to entire music programmes. Karageorghis et al. (2006a) suggested that although fast-tempo music was preferred at high-intensity exercise, continued exposure to such music during an exercise bout would lead to negative psychological outcomes such as boredom and irritation. In their 2008 study, Karageorghis and colleagues examined a medium-tempo condition, a fast-tempo condition, a mixed-tempi condition (tracks arranged in the order medium-fast-fast-medium-fast-fast; see Szabo, Small, & Leigh, 1999), and a no-music control condition while participants walked on a treadmill at 70% maxHRR. Towards the end of each condition, participants completed measures of music preference (similar to Karageorghis et al., 2006a), three Intrinsic Motivation Inventory (IMI; Ryan, 1982) subscales (interest-enjoyment, pressure-tension, and effort-importance), and global flow (Jackson & Eklund, 2002). Their hypothesis that the mixed-tempi condition would yield the most positive outcomes was refuted owing to the medium tempo condition yielding the most positive outcomes. The authors suggested that these results, and those recorded in their 2006 study, indicated a step change in preference between 70% and 75% maxHRR. This level of exercise intensity likely represents a shift in energy production (from predominantly aerobic to predominantly anaerobic) and is the point at which participants become more acutely aware of physiological sensations (Rejeski, 1985; Tenenbaum, 2001).

Given the inconclusive results of their 2006 and 2008 studies, Karageorghis and his colleagues sought to address the exercise heart rate-music tempo preference relationship using a more exacting methodological approach. They hypothesised that rather than the linear relationship hypothesised by Iwanaga (1995a, 1995b), the relationship between heart rate and music tempo preference would be quartic (three points of inflection) in nature. They predicted that the relationship would be somewhat linear during the early stages of an exercise bout, but thereafter, during moderate-to-high intensity exercise, both medium and fast tempi would be preferred. At exercise intensities beyond 75% maxHRR, fast tempi would be preferred and the linearity of the relationship is resumed. Finally, they expected a plateau in music preference higher intensities of exercise (i.e., > 80% maxHRR) representing a ceiling effect. The flattening was owing to a lack of familiarity of such high tempi in everyday listening situations (Berlyne, 1971; Karageorghis et al., 2006a).

In the third study in this series, Karageorghis et al. (2011) found a significant main effect for music tempo that was associated with a large effect size further demonstrating that this musical quality plays an important role in determining music preference during exercise. There was a significant cubic relationship ($p < .001$) between exercise heart rate and music-tempo preference. A key finding was that exercisers preferred a narrow tempo band of 125–140 bpm across a wide range of exercise intensities, from 40% to 90% maxHRR. Figure 2.9 shows the difference between the hypothesised and observed relationship. These findings underlined the importance of exercise intensity in determining music tempo preference. Taken in conjunction with the findings of Karageorghis et al. (2008), it seems plausible that music preference is an important variable in shaping the exercise experience. A recommendation was made that future studies should seek to investigate the associations between music preference and a range of affective and motivational outcomes.

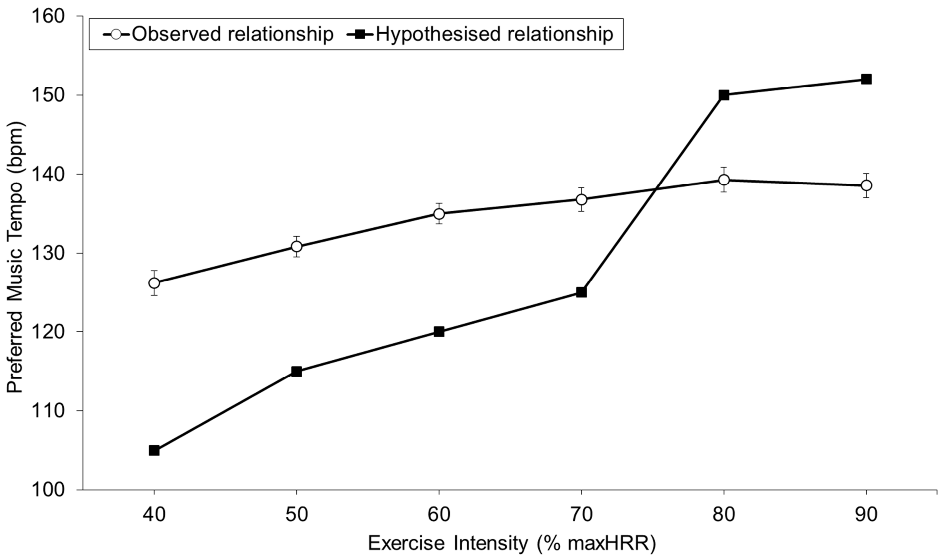

Figure 2.9. Plot of a hypothesised and observed exercise heart rate-music tempo relationship across a range of exercise intensities based on data presented by Karageorghis et al. (2011).

2.7 Factors Influencing the Effects of Music Use in Sport and Exercise

There are several characteristics that have been identified as key in determining musical preferences (e.g., age and gender). Much of the research pertaining to these characteristics has been conducted outside of sport and exercise, but some studies in sport and exercise contexts have offered insight into the influence of these characteristics (e.g., Priest & Karageorghis, 2008; Priest et al., 2004). These characteristics ultimately contribute to the familiarity of a musical idiom and it is this familiarity, along with complexity, that is a significant determinant of musical preference.

2.7.1 Familiarity and complexity. Berlyne's (1971, 1974) theories of experimental aesthetics remain relevant for contemporary research into music in exercise and sport. Berlyne described the significant influence that the complexity of a track has on liking and, as mentioned earlier, it was proposed that music with a moderate degree of arousal potential would be most liked (i.e., an inverted-U relationship). His theory stated that as the complexity of music increases it possesses more arousal potential (North & Hargreaves, 2008, p. 78). Berlyne also theorised that unfamiliar pieces of music are more arousing than familiar pieces. North and Hargreaves considered the interaction between the familiarity of a piece of music and its subjective complexity. They contended that when a piece of music is new to a listener it possesses a lot of new information. However, the listener knows the piece of music better with repeated listening and the music becomes more predictable. As familiarity increases, the subjective complexity of the piece decreases; therefore, repeated listening to a track would cause it to move from left to right along the inverted-U between liking and complexity (see North & Hargreaves).

The assertion that subjective complexity is related to liking in an inverted-U pattern has received preliminary empirical support in a music and exercise context (i.e., North & Hargreaves, 1996). North and Hargreaves asked participants of aerobic exercise and yogic exercise classes to listen to five music excerpts (new age/ambient house music) and rate their liking for each track as well as how complex the track was. Complexity was described in line with Berlyne's (1971) definition and participants were asked to rate the music by "the extent to which it was difficult to predict what would happen next in the excerpt, how elaborate the excerpt was, and how surprising the variations within the excerpt were" (p. 540). The inclusion of three criteria in the question (compound question) presents a substantial limitation of this work; the response to each question may have been different but the participants were unable to express this. Nevertheless, the results showed a broadly consistent relationship with the inverted-U prediction; although were not significant for the aerobics group. This study was undertaken in a naturalistic environment but the music presented to participants was deliberately unfamiliar. Nonetheless, in non-experimental conditions, people will listen to music styles they are familiar with. There are several key characteristics that help shape familiarity with certain music styles, including age and socio-cultural background.

2.7.2 Age as a factor influencing responses to music. The influence of age can also be linked to Berlyne's (1971, 1974) theory concerning musical preference. Hargreaves and Castell (1987) argued that older people are more familiar with a wider range of music pieces and styles owing to enculturation. Therefore, the inverted-U relationship between complexity and liking would apply meaning that pieces and styles that are too complex for children should be of an optimal complexity for older people, and vice versa. In their 1987 study, they found that familiar melodies did have an inverted-U relationship with increasing age, and also that unfamiliar melodies showed a similar pattern but with a later age peak in liking. North and Hargreaves (2008) speculated that this offers some support for why liking of complex music (such as classical or jazz) is so low among young people.

Studies that have explicitly examined the influence of age on music preference in sport and exercise contexts are rare. In a study by Priest and Karageorghis (2008), there was general consensus among interviewees that a person's age influences their response to music during exercise. Several participants expressed an affinity with the music of their teenage years or their early twenties, a time in their lives when they felt most affected by popular culture. Two of the group exercise leaders who were interviewed emphasised the importance of selecting music from an appropriate era when teaching older exercise participants. These findings support those of Priest et al. (2004).

The study by Priest et al. (2004) indicated that age can play a significant role in music preference during exercise. Stimulating aspects of music such as faster tempo and greater sound intensity (volume) were preferred by younger participants, and the number of participants reporting a motivation response to this music receded with age; so music was generally more important to young adults in this context. In addition to reporting that they were less likely than younger participants to be motivated by music, the older participants felt that music was less important during exercise. Although there is limited data on the effects of age on music preference during exercise, the existing evidence supports the notion that age should be a consideration when selecting appropriate music for experimental testing (see Karageorghis & Terry, 1997).

2.7.3 Socio-cultural background. North and Hargreaves (2008) disputed the assertion from Christenson and Roberts (1998) that the influence ethnicity has on music preference is "too obvious to question" (p. 84). There are several studies that indicate the link between ethnicity and music preference is not as clear cut as "a musical apartheid" (North & Hargreaves, p. 101) would suggest (e.g., Bryson, 1996; McCrary, 1993). There is limited research exploring the link in sport and exercise. Karageorghis and Terry (1997) suggested that socio-cultural background (comprising social class, area of residence, ethnicity, and peer group) is an overlooked research area and presented a number of studies (Hohler, 1989; Lucaccini & Kreit, 1972) that demonstrated the influence that socio-cultural background had on music preference.

Of the limited music and exercise research on the influence of socio-cultural background, Priest and Karageorghis (2008) showed that the influence is not always in the expected direction. They reported a male exercise participant in his twenties developed a preference for listening to rap music during exercise, a musical idiom that was not typically representative of his cultural background. A similar example is that of Michael Phelps, a Caucasian swimmer from Towson, Maryland where the 87% of the population are classified as White (http://www.census.gov/), has expressed a strong preference for hip hop and rap (http://content.time.com/time/arts/article/0,8599,1612765,00.html). There is sufficient evidence to suggest that factors contributing to socio-cultural background are influential factors in music preference, but there is insufficient evidence to draw conclusion about the strength and direction of such factors.

2.7.4 Sex (women and men) as a factor influencing response to music. The influence of sex on a number of emotional indices is noteworthy. Brody and

Hall (2009) stated that females report greater intensity for empathy and sympathy; positive experiences (joy, affection, warmth, well-being, and love); and dysphoric experiences (sadness, depression, shame, anxiety, fear, and embarrassment). There are few emotions that males report to be more intense; contempt, loneliness, pride, confidence, excitement, and guilt (Brody & Hall). The significant influence of sex on emotion has translated equivocally in responses to music. North and Hargreaves (2008) reported early experimental work wherein males and females were equally responsive (Sopchack, 1955), but Winold (1963) reported a greater responsiveness from females. More recent research has been unable to produce conclusive results, but there does appear to be a trend towards females demonstrating a preference for *softer* pop music and males preferring *harder* contemporary music (e.g., Christenson & Peterson, 1988; Colley, 2008). Colley described the music styles preferred by men to be rock and reggae whereas women preferred chart pop music. The only music style that did not demonstrate a gender difference was rap.

Studies have yielded equivocal results when examining the differences between sexes in music and physical activity. Gfeller (1988) reported no differences in music preference during exercise between the sexes, but Karageorghis et al. (2010) found that females derived greater benefit from music during circuit training type exercises than males. Perhaps the components of music provide a more accurate method by which to examine sex differences. Priest et al., (2004) found that males preferred a more pronounced bass line compared to females, which is similar to the findings outside of on exercise context. Crust (2008) found that females gave greater importance to melody while listening to asynchronous music played during circuit training. In sum, the role of age, sex, and other personal variables in musical reactivity within physical activity and exercise contexts is currently a underexplored area (Karageorghis & Priest, 2012b).

2.7.5 Environmental factors. Beyond characteristics of the music listener, there are other factors that influence responses to music in exercise and sport contexts. One such factor is the time point at which music is listened to (before, during, or after an activity) and this has previously been discussed in Section 2.5. Two additional factors are deemed of relevance for the present programme of research and are discussed herein.

2.7.5.1 Location of activity. Studies have sought to examine the effects of music in exercise and sport across a variety of environments (e.g., laboratory, aerobic classes, and Olympic Games; Hutchinson et al., 2011; North & Hargreaves, 1996; Karageorghis & Terry, 2006). A key aspect of theories on motivation and aesthetics is the situation in which the individual listens to the music; the responses to stimulus depend heavily on the context in which they are experienced (North & Hargreaves, 2008). There is a body of literature that has established that responses to exercise differ depending on whether it is conducted indoors or outdoors (e.g., Hug, Hartig, Hansmann, Seeland, & Hornung, 2009; Pretty, Peacock, Sellens, & Griffin, 2005). A principal reason for conducting experimental studies indoors (i.e., in the laboratory) is the extent to which extraneous variables can be controlled (e.g., wind, rain, human interference, etc). When a study is conducted in the field there are many factors that are rendered beyond the control of the researcher. Nonetheless, such an approach offers greater ecological validity than a similar study conducted under experimental conditions. There are currently no studies that have directly compared the effects of music and exercise between indoor and outdoor locations.

It has been shown that exercise location can influence a number of variables (e.g., Harte & Eifert, 1995; LaCaille, Masters, & Heath, 2004). In their study, LaCaille et al. compared the effects of treadmill, indoor track, and outdoor running on perceived exertion, affect, and satisfaction. The outdoor setting was found to be more beneficial than indoor settings in terms of affect, RPE, satisfaction, and performance. An article by Tenenbaum et al. (2004) included three studies examining the effect of music on running perseverance and coping with effort sensations with two studies conducted in the laboratory and the final study on a cross-country course. The first two laboratory-based studies included participants running at 90% $VO_{2\ max}$ while listening to a variety of music selections; measures of heart rate, RPE, discomfort were taken along with responses to questions about the music. However, the only dependent variable measured in the outdoor run was completion time; therefore comparisons could not be made between the responses to the music conditions by exercise location. If, hypothetically, questions pertaining to the music had been taken following the outdoor run, the study could likely have been criticised on the grounds that exercise intensity was not standardised, and this is of critical concern for music and exercise researchers.

The balance between laboratory-based work and naturalistic data collection is particularly delicate in this field of research as much of the power of music is owing to the context in which it is heard. Researchers may be underestimating the power of music during exercise by exploring the effects of music under laboratory conditions. However, given the preliminary stage of investigations regarding the influence of specific components of music during exercise, it seems appropriate to conduct experiments under tightly controlled conditions.

2.7.6 Method of music delivery. The delivery of music during exercise has used two methods: speakers or headphones. There have been no studies that have explored the relative effects of music delivery via speakers or headphones with studies using one or the other. A rationale for using either form of music delivery is not often presented. A number of studies have used headphones as a method of music delivery (e.g., Birnbaum, Boon, & Huschle, 2009; Brownley, McMurray, & Hackney, 1995; Edworthy & Waring, 2006; Elliott, 2007). Edworthy and Waring found that listening to music during exercise, especially loud and fast music, led to their participants experiencing more positive affect during short-duration treadmill exercise. Similarly, a number of studies have used speakers to deliver musical stimuli during exercise tasks (e.g., Hutchinson et al., 2011; Karageorghis et al., 2006; Karageorghis et al., 2008; Karageorghis et al., 2011) and found similar results. Although this represents a rather simplistic view, there is no evidence to suggest that the use of either headphones or speakers alters the response of listening to music during exercise. However, from a safety perspective it seems appropriate to deliver music through speakers during exercise owing to increased inner-ear pressure during exercise, and an increase in pressure can lead to temporary hearing loss (Lindgren & Axelsson, 1988). A practical advantage with delivering music via speakers rather than headphones is that the researcher can better control for sound intensity (volume) and be immediately aware if there are any technical issues (e.g., distortion, breaks, skipped tracks, etc) with the music.

2.8 Consequences of Music Use in Sport and Exercise

A wide range of benefits have been associated with the application of music in exercise and sport (see Karageorghis & Priest, 2012a, 2012b). Of interest to the current research programme are those benefits associated with enhancing the experience of exercise rather than ergogenic benefits. The variables presented herein do not represent an exhaustive list of benefits associated with the application of music during exercise but are considered of particular relevance to the exercise experience.

2.8.1 Affective responses to music and exercise. The direct measurement of affect in music and exercise studies has become more frequent over the past decade. There were few studies prior to 2004 (e.g., Boutcher & Trenske, 1990; Seath & Thow, 1995) that sought to include affect as a dependent variable and this was reflected in the omission of affect in both the 1999 conceptual model (Karageorghis et al., 1999) and the 2006 model (Terry & Karageorghis, 2006). Recent studies have shown that music can have a positive influence on affective valence during exercise, and this influence appears to hold regardless of exercise intensity or the synchronicity of the music (Karageorghis & Priest, 2012b). The effect of well-selected music (i.e., music selected with consideration of participant and task characteristics) has been associated with increases in positive affect greater than 10% (e.g., Hutchinson et al., 2011; Karageorghis et al., 2009). There appears to be compelling evidence that although music cannot alter *what* an individual feels (RPE) while exercising at high intensities, it can impact upon *how* they feel (Hardy & Rejeski, 1989; Hutchinson et al.; Shaulov & Lufi, 2009).

A series of studies by Elliott and colleagues (Elliott et al., 2004; Elliott, Carr, & Orme, 2005; Elliott, 2007) examined the influence that music had on affect during cycle ergometry tasks. Each study employed the Feeling Scale (Hardy & Rejeski, 1989) to measure differences in affect between music and no-music conditions. The studies found a consistent result; music enhanced in-task affect compared to the no-music conditions. Although there is mounting support for the notion that music enhances affect, some studies (e.g., Lim, Atkinson, Karageorghis, & Eubank, 2009) found no difference in affective valence between music and control conditions. Lim et al. assessed in-task affective responses using the Positive and Negative Affect Schedule (PANAS; Watson, Clarke, & Tellegen, 1988) during a 10 km time trial on a cycle ergometer while participants listened to music conditions (introduced at different times during the trial) or completed a trial without music. However, the authors acknowledged that the PANAS may not have been the most appropriate scale to assess affect (see Ekkekakis & Petruzzello, 2001).

Studies examining the effects of music and exercise have predominantly employed the Feeling Scale (Hardy & Rejeski, 1989) to measure affect (e.g., Boutcher & Trenske, 1990; Elliott, 2007; Karageorghis et al., 2009). The scale is an 11-point bipolar scale ranging from -5 (very bad) to +5 (very good) that was designed to evaluate the core of emotions (pleasure/displeasure) rather than the various categories of emotions (Hardy & Rejeski). The Feeling Scale (Hardy & Rejeski) is often used in conjunction with the Felt Arousal Scale (Svebak & Murgatroyd, 1985). Ekkekakis (2013) suggested that the use of these two scales in tandem strengthened the discriminant validity as the scales have different formats (e.g., different number of response options) which requires participants to consider their responses independently for each scale.

An alternative tool that has been used extensively in mainstream psychology research but in only a few studies within the music and exercise literature (e.g., Bishop, Karageorghis, & Kinrade, 2009), is the Affect Grid (Russell, Weiss, & Mendelsohn, 1989). The Affect Grid is based on the circumplex model of affect (Russell, 1980; see Figure 2.3) and encompasses affect and activation within two dimensional space. The Affect Grid provides two scores, one for pleasure–

displeasure and another for low-to-high arousal. It was designed for when participants are required to make either rapid judgements, or a large number of judgements (Russell et al., 1989).

2.8.2 Behaviour change. One of the most significant challenges facing researchers in sport and exercise is presenting evidence that interventions lead to meaningful changes in physical activity. There is a distinct lack of longitudinal studies investigating music and exercise programmes and their influence on long-term behavioural changes. To date there is only one study that has examined the influence of music in an exercise programme and the effects on exercise adherence. Annesi (2001) reported that over a 14-week period there was a trend towards greater attendance at a health facility when participants were exposed to an intervention that included self-selected music and television when compared to a music only, television only, and control condition. Although this study demonstrated high ecological validity, there were significant weaknesses specifically with the small sample size which may have led to underpowered statistical analysis.

Researchers have employed self-report *behavioural intent* items that have sought to gauge the influence of a variety of factors on physical activity in the future (e.g., motivation profiles: Vlachopoulos, Karageorghis, & Terry, 2000; autonomy support and exercise motives: Wilson & Rogers, 2004). However, this approach is yet to be adopted in music and exercise studies and presents a viable option for researchers if long-term monitoring of participants is not feasible. There is some evidence to suggest that the use of self-report behavioural intent items is a valid technique to predict future behaviour (e.g., Courneya & McAuley, 1993; Courneya, Nigg, Estabrooks, 1998). At present, the only viable option for music and exercise researchers is to infer what effects music might have on long-term behaviour. This premise is based in the developing research area examining the relationships between acute affective responses and exercise adherence (e.g., Williams et al., 2008).

2.8.3 Effects of music and exercise on flow state. Flow state has been an outcome measure employed in several music and exercise studies (e.g., Karageorghis et al., 2008; Pates et al., 2003). The application of both pre-task and in-task music has been found to enhance flow states. Pates et al. acknowledged that “the mechanism by which music interventions increase.…the experience of flow is not known” (p. 425). However, they did suggest that music may impact flow by enhancing pre-performance mood. Karageorghis et al. offered some explanation as to why flow has been frequently studied in music and exercise research design. In a state of flow, an activity is enjoyable in its own right and is not pursued in order to derive external rewards or benefits (Csikszentmihalyi, 1997). Music is purported to enhance enjoyment, and flow state provides an indication of enjoyment derived from activity, therefore if the activity is perceived to be enjoyable there is a greater likelihood for flow to occur.

The studies that have measured the effects of music on flow have employed the Flow State Scale (FSS; Jackson & Marsh, 1996), and the Flow State Scale-2 (FSS-2; Jackson & Eklund, 2002). These scales were grounded in Csikszentmihalyi’s (1990) nine-dimensional conceptualisation of flow. The original scale comprised 36 items that tapped nine factors (each reflecting one of the nine dimensions of flow). However, the FSS was criticised on statistical (Vlachopoulos et al., 2000) and conceptual grounds (Csikszentmihalyi, personal communication, cited in Jackson & Eklund). The scale was redeveloped in light of such criticisms and the FSS-2 is psychometrically superior to the original FSS and displays a more stable factor structure (Karageorghis et al., 2008). Jackson, Martin, and Eklund (2008) developed a shortened version of the FSS-2 (S FSS-2) that included 9 items (each one represented a dimension of flow). This brief counterpart was presented as a viable option when time for completion of questionnaires is a consideration, and when flow is not a central construct in the study (Jackson et al.,).

2.8.4 Effect of music on dissociation. Terry and Karageorghis (2006) listed dissociation as a potential consequence of applying music in exercise and sport. The notion of dissociation is couched in Rejeski's (1985) parallel processing model wherein attentional capacity is limited (see Section 2.6.2). There is evidence to support the claim that music promotes dissociation but this is limited to application during low-to-moderate exercise intensities. Boutcher and Trenke (1990) first discussed dissociation in an exercise and music context and their findings supported the load–dependent hypothesis of Rejeski. They found that music did not lower RPE relative to the control condition at the moderate and higher workloads and suggested this was because physiological cues dominated processing capacity.

Szabo et al. (1999) found that listening to music during a cycle ergometry task enhanced performance, and they suggested that music acted as a distracting stimulus that prevented focus on fatigue. However, at higher levels of exercise intensity (i.e., above 70% maxHRR), the influence of music depends on its arousing qualities. Elliott et al. (2005) also examined the effects of music on a cycle ergometry task and suggested that music blocked the transmission of internal sensations of fatigue. This dissociative effect was cited as a possible reason for the enhanced performance of music conditions compared to a no-music control in the Elliott et al. study. Crust and Clough (2006) offered support to the findings of Szabo et al. as they found that motivational music led participants to endure a dynamic strength test for longer. Crust and Clough cited attentional dissociation as a likely mechanism that underpinned the enhanced performance.

The argument for the dissociative effects of music is not one-sided. Johnson and Siegel (1987) examined the effects of active (arithmetic task) and passive (music) attentional manipulation on short-duration treadmill exercise. Participants exercised at 60% and 90% $VO_{2\ max}$ and while solving mathematical problems or listening to music. Participants reported lower RPE during the maths condition compared to the music or control conditions. Notably, the difference between the conditions was greater during the higher intensity condition. Therefore, the results appear to contradict the load-dependent hypothesis. Further, the findings indicate that active distraction has a more marked effect on perceived exertion than passive distraction.

The power of music to capture attention is often inferred by researchers without direct measurement (e.g., Crust & Clough, 2006; Szabo et al., 1999); indeed there have been no music and exercise studies that have directly measured attentional focus. The measurement of attention poses several challenges; arguably the greatest challenge concerns assessing the attentional focus of a participant without the measurement altering their focus. Schomer (1986) collected participants' verbalised thought processes as they ran a marathon, and Hutchinson and Tenenbaum (2007) employed this approach in their study examining attentional focus during cycle ergometry tasks. Although this approach does not rely on retrospective reports, there are several other concerns. There appears to be a significant disparity between the frequency of associative thoughts recorded using Schomer's (1986) method and other association/dissociation literature (Masters & Ogles, 1998). It was suggested that this method could increase the amount of associative thoughts and would limit the capacity to dissociate owing to the invasive nature of the approach (Masters & Ogles).

Tammen (1996) found the one-question scale to be an efficient and valid measure of attentional strategies used during effort engagement of elite runners. His study found that attentional focus changed as exercise intensity increased. Participants reported focusing internally and externally during a submaximal run, but focused predominantly internally during a maximal run. Participants' attentional focus was measured immediately after the task with them indicating a point on a line (with association and dissociation at either end) that matched their cognition. Participants were asked to indicate whether they were focusing on their body or on distracting thoughts (Tammen, 1996).

2.8.5 The effects of music on mood. The assessment of mood immediately following the application of music during exercise could be regarded as a controversial area. As described earlier (see Section 2.2.1), moods are diffuse and unfocused often without a specific trigger (Beedie et al., 2005). If this description and distinction from emotions and affect is accepted, then the notion that music used during exercise can alter mood is questionable. Nonetheless, some studies have included mood as a dependent variable within the design.

Hayakawa et al. (2000) asked participants to complete the Profile of Mood States (POMS; McNair, Lorr, & Droppelman, 1971) immediately after bench-stepping exercise tasks that were conducted with and without music. There were significant differences in mood between the music and no-music conditions with participants reporting higher vigour following the music condition. More recently, Biagini et al. (2012) examined changes in mood following the completion of strength exercises (bench press and squat jump) while listening to self-selected music or no-music. Participants completed the POMS immediately before and after three sets of the strength exercises, and results showed that listening to self-selected music increased vigour, tension, and fatigue. Despite an increase of tension and fatigue being a seemingly negative response to the music, participants increased their performance while listening to their self-selected music.

Perhaps the most appropriate way to utilise mood in music and exercise research is to assess mood state and control for this factor in the analysis. Simpson and Karageorghis (2006) intended to adopt this approach in their study examining the effects of synchronous music on 400-m sprint performance. However, owing to no statistical difference in mood scores they had no need to include mood as a covariate. They used the Brunel University Mood Scale (BRUMS; Terry, Lane, Lane, & Keohane, 1999) which is a 24-item inventory that measures six dimensions of mood (anger, confusion, depression, fatigue, tension, and vigour). The scale has demonstrated acceptable psychometric properties including Cronbach alpha scores ranging between .75 and .86 (Terry et al., 1999).

The BRUMS sought to advance the POMS by creating a tool that was appropriate for use with adolescents. However, similar criticisms could be made of both tools; an inclusion of only six dimensions does not encapsulate the entire domain of mood (Ekkekakis, 2013). Further, the tools can only reflect absence of negative mood states and are not able to reflect the presence of positive states. Alternative mood states (e.g., cheerful, relaxed) might be of more relevance in health behaviour research (Ekkekakis).

2.8.6 Ratings of perceived exertion. Ratings of perceived exertion (RPE) fall under the category of psychophysical effects of music (Karageorghis & Priest, 2012a). RPE is one of the most frequently assessed outcomes in music and exercise research (e.g., Bharani, Sahu, & Mathew, 2004; Boutcher & Trenske, 1990; Karageorghis et al., 2009; Nethery, 2002). The pattern of results that has emerged seems to indicate the music can influence RPE at low-to-moderate exercise intensities but is ineffective beyond this. This pattern is in line with Rejeski's (1985) parallel processing model, and is also consistent with Tenenbaum's model (2001). To exemplify this pattern, Boutcher and Trenske found a reduction in RPE was while listening to self-selected music during low-to-moderate intensity exercise on a cycle ergometer. Similarly, Bharani et al. compared self-selected music with no-music and found that RPE was lower during submaximal treadmill exercise while participants listened to music. During a supramaximal task (Wingate protocol), Hutchinson et al. (2011) found that participants reported no differences in RPE between a music condition and a no-music condition. The difference in exercise intensities across these three studies exemplifies the typical pattern of RPE findings.

In music and exercise research, the sole psychophysical measure is Borg's RPE scales (1982, 1998). The 15-point scale has been used in the majority of studies (e.g., Birnbaum et al., 2009; Boutcher & Trenske, 1990; Szmedra & Bacharach, 1998), but the CR10 scale has also been employed, and has gained popularity given that it has ratio scale properties (e.g., Bharani et al., 2004; Karageorghis et al., 2009).

2.8.7 Psychophysiological effects of music. Psychophysiological effects refer to the physiological correlates of music's psychological effects (e.g., changes in heart rate or blood pressure; Karageorghis & Priest, 2012a). Heart rate has been measured in numerous studies and, as mentioned previously, was the principal dependent measure in early investigations (e.g., Ellis & Brighouse, 1952; Hyde & Scalapino, 1918). More recent investigations have also included heart rate as a dependent measure and results are somewhat inconclusive as to whether music influences heart rate during exercise. Schie, Stewart, Becker, and Rogers (2008) found that music did not influence heart rate or plasma lactate during a submaximal cycling task. The nonsignificant effect of music on heart rate reported by Schie et al. offered support for previous work (e.g., Boutcher & Trenske, 1990; Nethery, 2002; Szabo et al., 1999) which also indicated that music had no effect on heart rate. However, Szmedra and Bacharach (1998) found that listening to music during exercise reduced heart rate. They suggested that music allowed participants to relax which reduced their muscular tension and thereby increasing blood flow. The inconclusive nature of the results regarding heart rate may be a consequence of the lack of information that a simple measure of heart rate can provide.

A number of studies have measured heart rate variability (HRV) and this measure has been shown to be sensitive to emotional responses to music (Kallinen & Ravaja, 2004; Krumhansl, 1997; Nyklicek, Thayer, & Van Doornen, 1997) and of basic emotions generally (Rainville, Bechara, Naqbi, & Damasio, 2006). The scientific value of the information inherent in HRV measures is beyond that which could be implied by mean heart rate has been established (see Kleiger, Miller, Bigger, & Moss, 1987). Autonomic influences on heart rate are remotely regulated by the central autonomic network (CAN), a network that includes cortical, limbic, and brainstem regions (Appelhans & Luecken, 2006).

Benarroch (1993) explained that the CAN receives input from visceral afferents concerning physiological conditions and also from sensory processing areas in the brain regarding the external sensory environment. The result of the combined input allows the CAN to adjust physiological arousal, including arousal associated with emotional expression and regulation, in response to changes in internal and external conditions (Appelhans & Luecken, 2006). Part of the output from the CAN is a transmission to the sinoatrial node through the sympathetic (SNS) and parasympathetic (PNS) nervous systems that directly influence heart rate. The autonomic nervous system, through an interplay of parasympathetic and sympathetic components, mediates changes in HR, blood pressure, and vascular tone during rest and exercise (ACSM, 2010). A measure of assessment for activity within the autonomic nervous system is HRV. HRV assesses beat-to-beat variations in R-R intervals and serve as a surrogate measure for parasympathetic activity (ACSM, 2010). An R-R interval is from the peak of one QRS complex to the peak of the next as shown by an electrocardiogram (Mosby, 2013; see Figure 2.10).

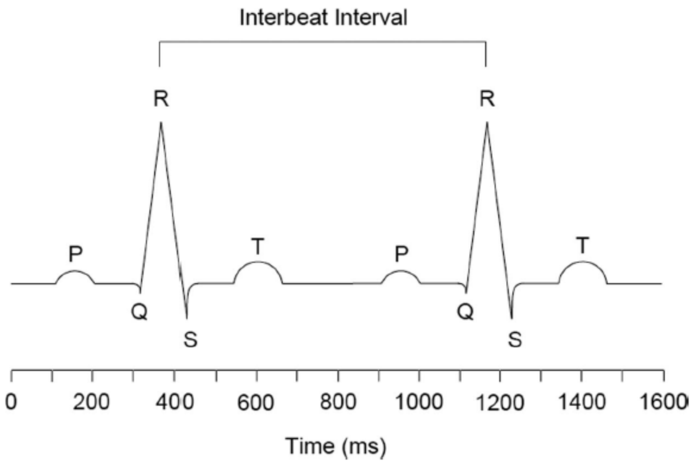

Figure 2.10. A stylised representation of the PQRST wave and the R-R interval. Reprinted from "Heart Rate Variability as an Index of Regulated Emotional Responding" by B. M. Appelhan, & L. J. Luecken. *Review of General Psychology*, *10*, p. 232. Copyright 2006 by American Psychological Association.

An electrocardiograph (ECG) is used to monitor the electrical conduction through the myocardium and to evaluate the beat-to-beat changes in the heart rate pattern (Berntson et al., 1997). HRV reflects the output of the CAN and, in turn, an individual's capacity to generate regulated physiological responses in the context of emotional expression (Appelhans & Luecken, 2006; Thayer & Lane, 2000; Thayer & Siegle, 2002). The cortical, limbic, and brainstem regions, that the CAN consists of, are responsible for many other key brain functions beyond that of emotional regulation. Given that HRV is remotely regulated as a result of input from these "large" brain regions, it is acknowledged that HRV is not a fully accurate measure of emotional regulation but may offer some insight into brain activity during exercise. Phan, Wager, Taylor, and Liberzon (2002) observed that many areas of the brain (including the cortical, limbic, and brainstem regions) are involved in emotion and these areas of the CAN are involved with emotional processing. From this it can be suggested that HRV (as an output of the CAN) will reflect emotional responses and is a valid, albeit indirect, measurement of emotional responses.

The measurement of changes in HRV frequency during exercise with music has received scant attention from researchers (e.g., Urakawa & Yokoyama, 2005; Yamashita, Iwai, Akimoto, Sugawara, & Kono, 2006) and studies to date have focused on recording HRV pre- and post-task. Urakawa and Yokoyama reported that music did influence HRV after exercise, but this was contrasted by Yamashita et al. who reported that music had no effect on the autonomic nervous system before and after submaximal exercise.

2.9 Methodological Considerations

The control of extraneous variables in a study design represents a significant challenge for any researcher. The following section describes some factors that researchers should consider when designing any study examining the effects of music and exercise. The selection of appropriate music, and how loud to play the music, are considerations that are specific to the area of music and exercise research. Further, there are methodological considerations that are not specific to music and exercise research but are salient in such designs (e.g., circadian rhythm, the menstrual cycle, and obstructive measurement).

2.9.1 Selection of appropriate musical stimuli.

2.9.1.1 Self-selected music vs. prescribed music. There have been three approaches to selecting music for use in sport and exercise studies. One approach is to allow participants to select their own music (e.g., Terry et al., 2012), the second approach is for the researcher to prescribe the music (e.g., Hutchinson et al., 2011), and the third approach is a compromise between the two (e.g., Karageorghis et al., 2006a). There is no clear consensus as to which approach should be adopted.

The principal benefit of self-selected music is that it almost guarantees that the participant will find the music enjoyable and motivating; therefore the music should be at its most potent and allow for its effects to be maximised. However, Karageorghis and Priest (2012a, 2012b) argued that experimental designs incorporating self-selected music risk alerting the participants to the nature of the study and therefore influencing behaviour through a level of expectancy. A further issue with employing self-selection is the non-standardisation of the music, and therefore the subsequent lack of generalisability of results.

Researcher-selected music provides the strongest option to ensure standardisation of music, and therefore allows for the most accurate recommendations for appropriate music to maximise any benefit. However, even if the music used in experimental trials is subject to careful consideration (see Karageorghis et al., 2006b) it may not be appropriate for all participants. A way to minimise this potential confound is to ensure the study is sufficiently statistically powered to minimise the influence of personal preferences.

An approach adopted by Karageorghis et al. (2006a) and Karageorghis et al. (2008) was to provide the participants with a choice of artists (Michael Jackson, Christina Aguilera, The Stereophonics; 2006) or genre (Rock or Pop; 2008) that had been standardised in terms of their motivational quotients (as per the BMRI methodology). This approach was employed in an attempt to minimise the opportunity for participants to exhibit an extreme dislike for a music selection.

2.9.1.2 Sound intensity (volume). The influence of sound intensity (volume) has been shown to be a significant factor in reactivity to music (e.g., Bishop et al., 2009). Tracks played at a higher intensity resulted in higher levels of arousal (Bishop et al.), and it has been suggested that loud music requires more processing than quiet music (e.g., Konecni, 1982). In light of this evidence, unless sound intensity is a dependent measure, researchers should take measures (use of decibel meter) to ensure the standardisation of this factor.

Beyond factors pertaining to outcome measures, researchers need to consider levels of sound intensity with regards to participant safety as persistent exposure to high levels can cause hearing loss. Alessio and Hutchinson (1991) reported that exposure to loud music can cause temporary hearing loss, including during submaximal exercise. Health and Safety guidelines (UK) stipulate that hearing protection must be offered to workers if noise levels exceed 85 dB (daily or weekly average exposure). There is also an exposure limit value of 87 dB, taking account of any reduction in exposure provided by hearing protection, above which workers must not be exposed. These guidelines are designed to protect against loss of hearing and/or tinnitus (permanent ringing in the ears).

2.9.2 Circadian rhythms. According to North and Hargreaves (1997), the time of day may have an influence on music preference. The regulation of bodily function varies diurnally according to *circadian rhythms*, therefore levels of energy, fatigue, and mood have different peaks throughout the day (Wefelmeyer & Kuhs, 1996). For example, energy levels usually peak in the evening and are lower in the morning compared to the afternoon or evening (Yoon, May, & Hasher, 1999). Strutton, Catley, and Davey (2003) concluded that maximum voluntary muscle force varies throughout the day, typically being low in the morning and high in the evening. As a consequence, researchers should seek to test participants at a consistent time of day if employing a repeated measures design.

2.9.3 Menstrual cycle. The menstrual cycle phase and the associated variation in female steroid hormones can affect athletic performance (Lebrun, Mckenzie, Prior, & Taunton, 1995) and mood states (Cockerill, Nevill, & Byrne, 1992). Lebrun et al. (1995) found that during the luteal phase a lower $VO_{2\ max}$ by almost 4 $ml.kg^{-1}.min^{-1}$ was recorded, which led to concomitant increases in perceptions of effort. Lebrun et al. suggested that the different ovulatory menstrual cycle phases have a minimal impact on most indices of performance, except aerobic capacity were the magnitude of effect varies on an individual basis.

It is established that mood changes occur among a high proportion of women during the few days before menstruation (Lentz, 2012). Cockerill et al. (1992) found total mood disturbance significantly higher during the premenstrual phase. From the Profile of Mood States (POMS) questionnaire, it was found that tension was significantly higher during the premenstrual phase compared to mid-cycle. Researchers should be mindful of such variations in mood and seek to account for this in study design.

2.9.4 Obstructive measurement. The effects of music rely heavily on the context in which it is heard as well as its composition. Researchers should be attentive to the protocols they employ to ensure they do not obstruct the enjoyment of music to a large degree. For example, flow state has been shown to be enhanced while listening to music during exercise (Karageorghis et al., 2008) but protocols such as that employed by Seath and Thow (1995) could limit the likelihood of participants achieving flow. They asked participants to respond to measures of RPE and affect every 30 s throughout a 15 min exercise task. A requirement for flow to occur is total absorption in an activity (Nakamura & Csikszentmihalyi, 2002), but a participant is unlikely to be able to absorb themselves in an activity with such an intrusive protocol. Further, the inclusion of obstructive equipment during experimental trials is unlikely to promote a state wherein music can be enjoyed (e.g., electroencephalography reporting cap; online gas analyser). If participants are to be constantly monitored throughout trials every effort must be made to ensure the measurement devices are as non-invasive as possible.

2.10 Rationale for the Present Research Programme

The rationale for this programme of research stems from the theoretical and empirical work presented in this review. The mechanisms underlying the effectiveness of music during exercise are not well understood (Karageorghis & Priest, 2012a), and this presents the most pressing challenge for the research area. Dissociation is often cited as a cognitive mechanism underlying the effects of music during exercise, but the veracity of this claim is not well evidenced. Further, ways in which to maximise the effects that can be derived from the application of music during exercise are essential in order that practitioners are able to provide a positive exercise experience for participants.

The line of research examining the exercise heart rate-music tempo preference relationship (Karageorghis et al., 2006a; Karageorghis et al., 2008; Karageorghis et al., 2011) has provided some evidence that the relationship is not linear as was previously hypothesised (cf. Iwanaga 1995a, 1995b). However, the stability of the proposed cubic relationship (Karageorghis et al., 2011) has not been established. Moreover, it is not known whether the relationship is generalisable to other exercise modalities (e.g., treadmill exercise). One of the limitations of this line of research is that relevance of the relationship to psychological outcomes (e.g., affect) has not been examined as previous studies were directed more towards establishing the nature of the relationship. Accordingly, the precise consequences of optimal music selection or poor selection at different exercise intensities are not fully understood.

The two conceptual models that have guided research efforts over the past 15 years included personal factors as important antecedents to the consequences of music use during exercise (Karageorghis et al., 1999; Terry & Karageorghis, 2006). Nonetheless, a recent review by Karageorghis and Priest (2012b) highlighted the need to further understand personal variables in musical reactivity within the exercise context. Personal factors such as age and gender have received some attention from researchers (e.g., Priest & Karageorghis, 2008; Crust & Clough, 2006), but the influence of individual difference characteristics (such as motivational orientation and dominant attentional style) on affective, cognitive, and behavioural consequences to music and exercise has been a largely neglected area. A fuller understanding of the influence that these personal factors can have on the consequences of music use during exercise might lead to more accurate recommendations on how to maximise the potential benefits.

There is growing evidence to suggest that acute affective responses to exercise have a significant influence on exercise adherence (e.g., Williams et al., 2008). However, there is a paucity of evidence relating to interventions aimed at enhancing the affective responses of participants during exercise. Ekkekakis's (2003) dual-mode model highlights the significance of the ventilatory threshold in the pattern of affective responses during exercise. Beyond ventilatory threshold, there is significant inter-individual variation in the affective responses to exercise wherein some people continue to experience exercise as pleasant but others experience a sharp decline in affect. Given that exercise participants, particularly those who have been sedentary and are beginning an exercise programme, are likely to exercise at intensities above the ventilatory threshold, there is significant gain to be made from interventions that can enhance the affective responses of participants beyond this key biological marker.

The affect-enhancing qualities of music have been established in a number of studies (e.g., Boutcher & Trenske, 1990; Elliott et al., 2005), but an investigation into the capacity of music to influence psychological outcomes (e.g., affect and attention) with reference to the ventilatory threshold has not yet been conducted. Moreover, the effects that multiple stimuli have on psychological outcomes during exercise intensities above and below the ventilatory threshold have received scant attention from researchers. The combination of music and video is representative of the distraction methods used in most gymnasia (Annesi, 2001), but the empirical investigation of such methods is distinctly lacking at the present time. Further investigations are warranted to address whether there is additional attentional processing demand when comparing a single stimulus (e.g., *asynchronous* music) with multiple external stimuli (e.g., the combination of music with video) during exercise. The three studies that comprise this programme of research present separate hypotheses and are prefaced with a specific introduction and rationale.

Chapter 3: On the Stability and Relevance of the Exercise Heart Rate-Music Tempo Preference Relationship

3.1 Introduction

There is a burgeoning literature on the psychophysical and ergogenic effects of music in the exercise domain (see Karageorghis & Priest, 2012a, 2012b for a review). A key concern for researchers is to identify the musical qualities that are germane to beneficial effects across the gamut of exercise settings. Experimenters have manipulated musical qualities such as intensity (volume), style, rhythm, harmony, and lyrical content (e.g., Bishop et al., 2009; Copeland & Franks, 1991; Crust & Clough, 2006). From both research and applied perspectives, one of the easiest facets of music to manipulate is its speed or tempo as measured in beats per minute (bpm). Tempo is thought to be a key determinant of musical response (e.g., Crust, 2008; Edworthy & Waring, 2006).

Neurophysiological and psychomusicological research has shown that the rhythmical qualities of music can have a stimulative effect on humans (e.g., Khalfa, Roy, Rainville, Dalla Bella, & Peretz, 2008). Entrainment theory (Thaut, 2008, pp. 39-59) and associated empirical investigation have provided a deeper understanding of how music affects the body's main pulses such as brainwaves, heart rate, and respiratory rate (e.g., Khalfa et al.; Large, 2000). Music appears to activate neural structures in a periodic way and stimulates the limbic and reticular activating systems of the brain which are thought to govern arousal (e.g., Lyttle & Montagne, 1992).

It has been postulated that preference for different music tempi should be affected by the physiological arousal of the listener and the context in which they hear the music (e.g., Berlyne, 1971, p. 70; North & Hargreaves, 2008). Thus when an individual's psychomotor arousal is high, it follows that they should prefer music with faster tempi. Moreover in situations that favour high arousal (e.g., during execution of highly motoric tasks), fast, stimulative music is likely to be preferred. Following two exploratory studies using musical excerpts and then entire music programmes (Karageorghis et al., 2006a; Karageorghis et al., 2008), Karageorghis and Terry (2009) argued that the relationship between physiological arousal and preference for music tempo may not be linear in nature. This was demonstrated in a subsequent study that used musical excerpts in four tempo categories that were played across six intensities while participants exercised on a cycle ergometer (40–90% maximal heart rate reserve [maxHRR]; Karageorghis et al., 2011; see Figure 3.1). At low exercise intensities (40–60% maxHRR) the relationship is positive and linear, and as intensity increases an *inflection point* (change of direction in the trendline) is reached at 60% maxHRR, leading to a more moderate pitch. A further inflection point occurs at approximately 80% maxHRR when the pitch of the line becomes negative; as exercise intensity increases further, the preference is for a slight reduction in tempo.

The *cubic* relationship—two points of inflection in the trendline—that was observed in the Karageorghis et al. (2011) study was attributed to three main factors. First, the majority of up-tempo popular music falls into a tempo band of 115–140 bpm (Karageorghis et al.); and, by extension, this is also the most familiar tempo band for most westerners. Second, the dip between 80 and 90% maxHRR occurs beyond the ventilatory or lactate threshold; thus the slight attenuation in tempo preference may reflect the automatic attentional switching that takes place during high-intensity exercise, which severely limits participants' ability to focus on external stimuli such as music (Rejeski, 1985; Tenenbaum, 2001). Third, fast-tempo music tracks (> 140 bpm) may contain too much information for the limited attentional capacity of the afferent nervous system or have too great an arousal potential, irrespective of participants' heightened level of physiological arousal (Berlyne, 1971, p. 70; Rejeski).

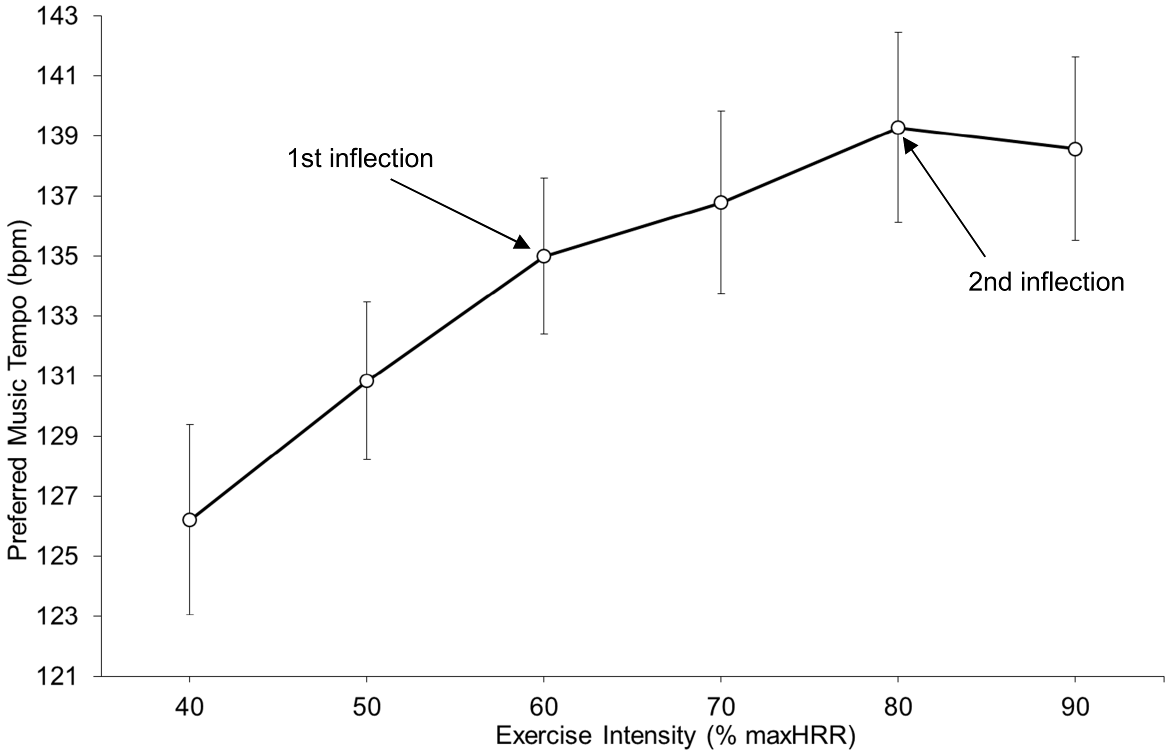

Figure 3.1. The cubic relationship between exercise heart rate and preference for music tempo reported by Karageorghis et al. (2011). Adapted from "Revisiting the Exercise Heart Rate and Music Tempo Preference" by C. I. Karageorghis, L. Jones, D. L. Priest, R. I. Akers, A. Clarke, J. Perry, … H. B. T. Lim. *Research Quarterly for Exercise and Sport*, *82*, p. 276. Copyright 2011 by American Alliance for Health, Physical Education, Recreation and Dance.

Using a sample of tennis players, Bishop et al. (2009) investigated how changes in the tempo and intensity of music influenced affective valence and choice-reaction task performance. Their results showed that fast-tempo music elicited emotional states that were more pleasant/arousing (as measured using the Affect Grid; Russell et al., 1989) compared to slow-tempo music, although there were no associated differences for reaction time. In a similar vein, Edworthy and Waring

(2006) examined the effects of music tempo and sound intensity (fast/loud, fast/quiet, slow/loud, slow/quiet) on self-selected speed of treadmill running. Fast music was associated with higher running velocities than either slow music or a white noise control condition. Although participants exhibited increased running velocities in the two fast-music conditions, there was no corresponding increase in perceived exertion. All four music conditions enhanced affect when compared to control with the influence of fast music being more pronounced. A limitation of this study was that music selections were made only with consideration of tempo, and no other aspects that contribute to its motivational qualities, such as harmony, lyrics, and extramusical associations.

One of the limitations in previous work that has examined the exercise heart rate-music tempo relationship is that the relevance of the relationship in terms of psychological outcomes has not been assessed (e.g., Karageorghis et al., 2006a, 2011). Such studies were directed more towards establishing the nature of the relationship rather than its consequences. Extant findings indicate that optimal music selection should be associated with positive affective states, increased activation, dissociative attentional focus, and higher state motivation (Hutchinson et al., 2011; Karageorghis & Terry, 1997; Karageorghis et al., 1999). Accordingly, the precise consequences of optimal music selection or poor selection at different exercise intensities are not fully understood.

The application of music during exercise is thought to promote a dissociative focus (see Terry & Karageorghis, 2006). This is based on the notion that music can serve to distract the listener during exercise and focus their attention externally and away from internal, fatigue-related cues. However, the dissociative effect of music is often inferred by altered levels of affect or ratings of perceived exertions (e.g., Elliott, 2007), and the capacity for music to elicit an external focus during exercise has yet to be directly assessed. The transition from a dissociative focus to an associative focus as a function of increasing exercise intensity has been conceptualised by Tenenbaum (2001), and supported empirically by Hutchinson and Tenenbaum (2007), and Connolly and Tenenbaum (2010). The study by Hutchinson and Tenenbaum is of most relevance to the present study owing to the similarity in exercise mode (treadmill running).

Hutchinson and Tenenbaum (2007) used a thought classification technique, similar to that of Schomer (1986), to assess associative/dissociative thoughts during cycle ergometry tasks performed at three different exercise intensities (50%, 70%, and 90% $VO_{2\ max}$). They found that thoughts became increasingly associative as exercise intensity increased, in line with Tenenbaum's model (2001). The shift in attentional focus was marked, with 22% of thoughts classified as associative during the low-intensity condition (50% $VO_{2\ max}$) but 93% of thoughts classified as associative during the high-intensity condition (90% $VO_{2\ max}$). When the data presented by Hutchinson and Tenenbaum are plotted, they reveal the point at which attentional focus switches from predominantly dissociative to predominantly associative. By interpolation, the intensity at which attentional focus switches is ~64% $VO_{2\ max}$ (see Figure 3.2). If music does lead to a dissociative focus during exercise, there should be a rightward shift in the switch-point from dissociative to associative focus, as there are more dissociative thoughts when music is applied. Figure 3.2 includes a plot of a hypothesised rightward shift in the switch from predominantly dissociative to predominantly associative attentional focus that music can elicit (i.e., greater dissociation, see Terry & Karageorghis, 2006). The plot showing the hypothesised music data is based on a music selection that has a tempo between 125–140 bpm as this tempo has previously been found to be the most preferred across a range of exercise intensities (Karageorghis et al., 2011).

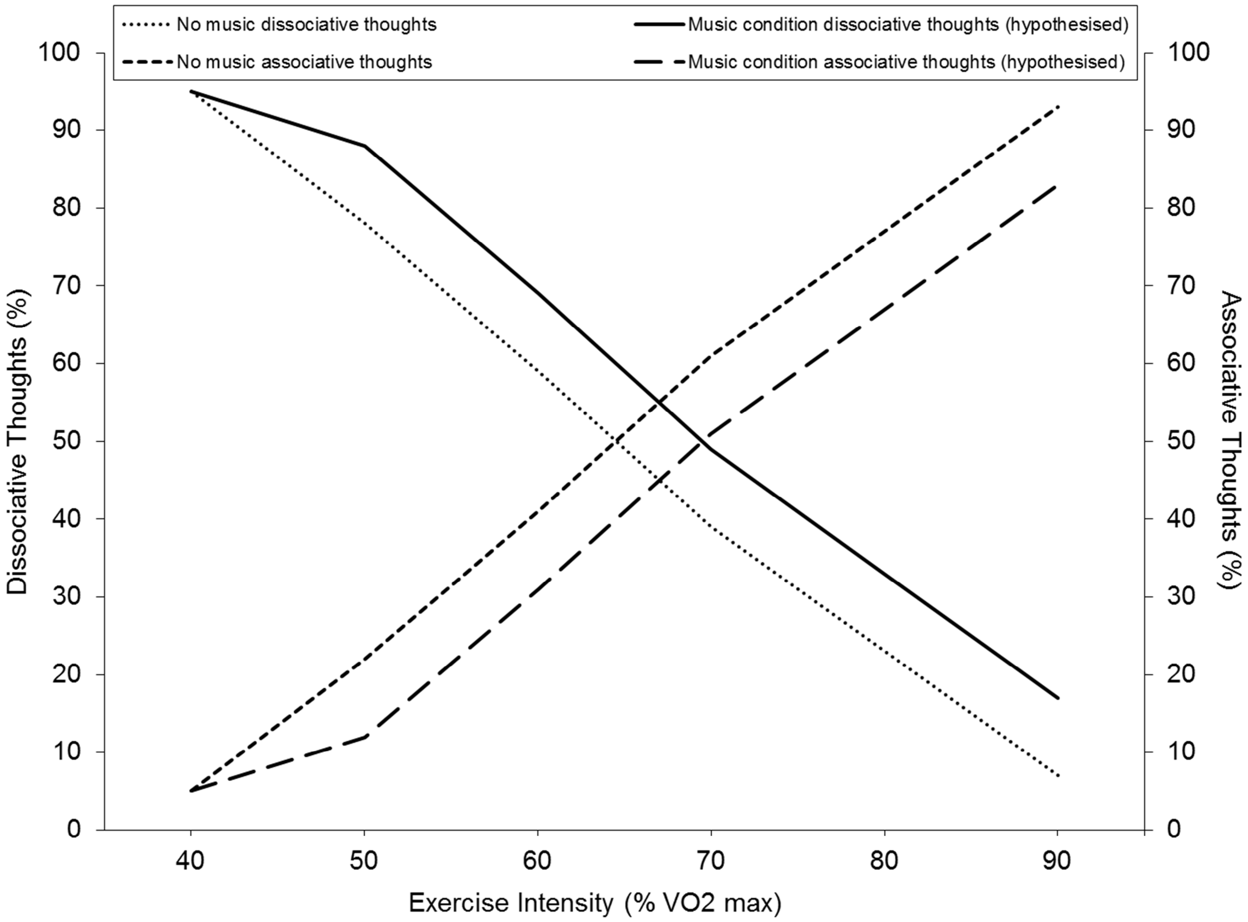

Figure 3.2. Data from Hutchinson and Tenenbaum (no music; 2007) plotted with data representing a hypothesised shift in attentional focus elicited by a music stimulus.

Further to the issues surrounding psychological outcomes, is the potential moderator variable of gender. Past research examining complex motoric tasks (e.g., circuit-type exercises) has shown that females are likely to derive greater psychological benefits from music than their male counterparts (e.g., Karageorghis et al., 2010). However, in the case of the simple motoric task employed in the present study, gender is not expected to have a moderating influence, either on the exercise heart rate-music tempo relationship or on associated psychological outcomes (see e.g., Elliott et al., 2005). Also, given that Karageorghis et al. (2011) employed a simple motoric task (cycle ergometry) it is not known whether their findings are generalisable to other such tasks (e.g., treadmill exercise). The motor patterns involved in walking/running are different to those involved in cycle ergometry, while the former is also a weight-bearing activity. This factor contributed to the rationale underlying a test of the stability of the heart rate-music tempo relationship.

The purpose of the next study in this line of work is to assess the stability of the cubic exercise heart rate-music tempo relationship (see Figure 3.1) using a different exercise modality to that employed by Karageorghis et al. (2011) and to examine a number of psychological outcome variables (affective valence, state attention, intrinsic motivation, and flow). Thus the present study is more ambitious in scope than preceding studies (Karageorghis et al., 2006a, 2008, 2011), meshes the best elements of those studies (e.g., a wide range of music tempi and exercise intensities), and aims to combine measurement of the relationship with an analysis of whether optimal tempo selection is associated with superior psychological outcomes. This will better enable practitioners to generalise extant findings to different exercise modalities and gauge the impact of tempo manipulations on a range of psychological outcomes (e.g., in-task affect, state attentional focus, flow state, intrinsic motivation).

3.1.1 Hypotheses

It was hypothesised that a cubic trajectory would emerge in the exercise heart rate-music-tempo preference relationship and that this would be similar in nature to that observed by Karageorghis et al. (2011) in cycle ergometry (H_1). A secondary hypothesis was that the music conditions would elicit a shift in attentional focus and result in significantly greater dissociation at each exercise intensity (see Figure 3.2; H_2). Thirdly, it was hypothesised that the most positive psychological outcomes would be associated with the most appropriate tempo for each intensity. Also there would not be differences between adjacent tempi bands (e.g., medium and fast or fast and very fast) with the exception of slow vs. medium (see Karageorghis et al., 2006a, 2011). Hence differences were expected to emerge between slow and medium, slow and fast, slow and very fast, and medium and very fast tempi (H_3). Sex was included as an independent variable but no differences were expected to emerge (H_4).

3.2 Methodology

The study received approval from the Brunel University ethics committee (see Appendix A) and participants provided written informed consent (see Appendix B).

3.2.1 Stage 1: Music Selection

A total sample of 73 volunteers (31 females and 42 males) who were homogenous in terms of age (M_{age} = 21.0 years, *SD* = 1.0, years), ethnicity (White), and had taken their secondary school education in the UK, took part in Stage 1 (see Karageorghis & Terry, 1997). The volunteers were drawn from the body of sports science undergraduates at Brunel University. An initial sample group of 65 volunteers (27 females and 38 males; M_{age} = 21.0 years, *SD* = 1.0 years) each nominated five musical selections suitable for treadmill exercise (see Appendix C). These nominations were used to establish a pool of tracks suitable for use in the experimental protocol of Stage 2. The 20 most frequently-nominated tracks that matched (± 4 bpm) the required tempi ranges for the experimental stage were then rated.

The 20 tracks were rated by a panel of eight (four male and four female) undergraduate sports science students (M_{age} = 21.3 years, *SD* = 1.6 years) according to their motivational qualities for treadmill exercise using the Brunel Music Rating

Inventory-2 (BMRI-2; Karageorghis et al., 2006b). The BMRI-2 supersedes the BMRI as it can be used by instructors *and* participants of music-in-exercise related activities. The psychometric properties of BMRI-2 are superior to its predecessor and it has been shown to be a valid and internally consistent tool (Karageorghis et al.).

This procedure for rating the tracks was undertaken to ensure that, although the tempi across tracks would differ, the tracks would be broadly equivalent in terms of their motivational qualities. Karageorghis et al. (2006b) recommended using the BMRI-2 in tandem with qualitative methods to elicit the optimum selection of music for an exercise setting. The BMRI-2 was used a wide-filter to identify musical pieces that were then considered on other grounds. The music used in the present study was selected following consideration of extra-musical associations, lyrical affirmations, musical idiom/genre, and date of release with reference to the age and socio-cultural background of experimental participants.

Following the BMRI-2 ratings and the qualitative steps taken to ensure appropriate music selection, one track was selected from each of the four required tempi ranges (slow, 95–100 bpm, *Buzzin'* by Mann ft. 50 Cent; medium, 115–120 bpm, *Stronger* by Kanye West; fast, 135–140 bpm, *On The Floor* by Jennifer Lopez ft. Pitbull; and very fast, 155–160 bpm, *Time* by Chase & Status). Minor digital alterations were made to the tracks to ensure the tempo was within the required ranges. The digital alteration of the tempi was conducted using software (Audacity 1.3; http://audacity.sourceforge.net/) that did not alter the pitch of the tracks. The present study sought to advance the methodology used in previous similar studies (Karageorghis et al., 2006; Karageorghis et al., 2008) by using the same tracks for all participants. Previous studies in this lineage had included procedures to ensure the motivational qualities of the tracks were similar but offered participants a choice of music. The present study removed this potential confound by not offering the participants a choice of music genre/artist to listen to during the experimental trials. The music genres of the experimental tracks were similar, were released within 4 years of each other, and achieved UK chart success (see Table 3.1).

Table 3.1

Details of the Tracks Used in the Experimental Trials for Study 1

Tempo	Track title	Artist(s)	Year of release	Record label	Genre	Highest UK chart position	BMRI-2 score
95 bpm (slow)	Buzzin'	Mann ft. 50 Cent	2010	Mercury	Hip Hop	6	23.88
115 bpm (Medium)	Stronger	Kanye West	2007	Roc-A-Fella	Hip Hop	1	26.00
135 bpm (Fast)	On The Floor	J-Lo ft. Pitbull	2011	Island	Electropop	1	27.50
155 bpm (Very Fast)	Time	Chase & Status ft. Delilah	2011	Mercury	Breakbeat	21	25.13

In the present study the term tempo was equated with the closely related concept of *meter*, pertaining to how the listener perceives the speed or rhythmical energy transmitted by a musical work. In popular music, there are many instances of tracks with relatively slow tempi (e.g. 80-95 bpm) that "feel" much faster to the listener due to the subdivision of beats (see Loehr & Palmer, 2009); for example tracks from the *rap* and *grime* genres. How fast music "felt", rather than tempo per se, was important and a simple finger-tapping exercise was employed to determine meter and ensure that it was identical to music tempo for each track.

3.2.2 Stage 2: Experimental Investigation for Study 1

Based on a power analysis with alpha set at .05 and power at .95 (Cohen, 1988) and a moderate effect size (partial $\eta^2 = 0.09$; Karageorghis et al., 2006a), a G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) calculation using the *as in SPSS* *option* indicated that 18 participants would be required. An extra four participants were recruited to protect the study against the possibility of experimental dropout and deletions due to outliers.

3.2.2.1 Participants. Twenty-two participants comprising 11 women (M_{age} = 20.3 years, *SD* = 1.6 years) and 11 men (M_{age} = 19.6 years, *SD* = 1.6 years) were recruited from the body of sports science undergraduates at Brunel University. The recruitment process included placing advertisements around campus and distribution of handouts at the training sessions of university hockey, football, rugby, netball, American football, and basketball teams. Undergraduate sport science students were also invited, via undergraduate course lectures, to participate. These participants had not taken part in Stage 1 of the design but did match the age profile, ethnicity, and educational background of the volunteers engaged in Stage 1. Participants were drawn from sports with a significant requirement for aerobic energy production (e.g., outfield players from weight-bearing sports) and all reported that they did not have a hearing deficiency.

3.2.2.2 Apparatus. A treadmill (Powerjog GXC200) was used for testing along with a wall-mounted stereo system (Tascam CD-A500) with four speakers located in each corner of the laboratory, and a decibel meter (AZ 8928 Sound Level Meter) to standardise music intensity at a safe level of 75 dBA (see Alessio & Hutchinson, 1991; Health and Safety Executive, 2005). Target heart rate was assessed by use of a heart rate monitor strapped to the chest of each participant and a sensor (Polar Accurex Plus) held by the experimenter.

3.2.2.3 Measures.

3.2.2.3.1 Music preference. Music preference was assessed using a single item based on a 10-point scale anchored by 1 (*I do not like it at all*) and 10 (*I like it* *very much*). This item essentially tapped *music liking* using the response set "based on how you feel right now, rate how much you like this track". Music liking is used synonymously with preference in the present study (and in the previous related studies of Karageorghis et al., 2006a; Karageorghis, et al., 2008; Karageorghis et al., 2011) given that *all* of the excerpts would need to be played at each exercise intensity with each participant giving a retrospective ranking in order for researchers to establish preference in the strict sense (i.e., rank order of tracks).

3.2.2.3.2 In-task affect. In-task affective valence was assessed using Hardy and Rejeski's (1989) 11-point Feeling Scale which has a single-item scale ranging from +5 (*very good*) to -5 (*very bad*). The scale has demonstrated satisfactory validity across three experiments reported by its originators that reinforced its merit as an index of in-task affect (Hardy & Rejeski).

3.2.2.3.3 Perceived activation. Perceived activation was assessed using Svebak and Murgatroyd's (1985) Felt Arousal Scale. This is a single-item scale ranging from 1 (*low arousal*) to 6 (*high arousal*) that has been shown to have a moderate-to-strong positive correlation with the arousal scale of the Self-assessment Manikin and the arousal scale of the Affect Grid (Ekkekakis et al., 2008).

3.2.2.3.4 Attentional focus. A measure of attentional focus was taken immediately after each trial to assess the participant's predominant attentional focus (association/dissociation) during the trial. A 20 cm bipolar scale with verbal anchors of "Internal focus (bodily sensations, heart rate, breathing, etc)" and "External focus (daydreaming, external environment, etc)" was used (Tammen, 1996). Participants were required to mark the scale with an "X" to indicate their predominant focus during the exercise bout and the level of internal or external focus was ascertained through measuring the distance from the left-hand point of the scale to the "X" in centimetres. That number was multiplied by 5 to give a score out of 100.

3.2.2.3.5 Flow state. The 9-item short version of the Flow State Scale-2 (S FSS-2; Jackson et al., 2008) was administered immediately after each condition. Items (e.g., "The way time passed seemed different from normal") are presented on a Likert scale anchored by 1 (*Strongly disagree*) and 5 (*Strongly agree*). The scale is associated with acceptable goodness-of-fit indices (Jackson et al., 2008) and scores from the scale have been shown to be internally consistent (α = .82; Martin, Tipler, Marsh, Richards, & Williams, 2006).

3.2.2.3.6 Intrinsic motivation. Items from two of the seven subscales of the Intrinsic Motivation Inventory (IMI; Ryan, 1982; interest-enjoyment [IE] and pressure-tension [PT]) were completed by participants immediately after each condition. Sample items include "I enjoyed doing this activity very much" (IE) and "I felt very tense while doing this activity" (PT). The items are rated on a 7-point Likert scale anchored by 1 (*Strongly disagree*) and 7 (*Strongly agree*). Scores from both IMI subscales have been shown to be internally consistent (IE α = .78; PT α = .68; McAuley, Duncan, & Tammen, 1989).

3.2.2.4 Establishing resting heart rate and a habituation trial. It was necessary for participants to exercise on a motorised treadmill at a constant speed of between 6 kph and 12 kph, and the treadmill velocity/gradient was increased in a linear manner to elicit work intensities of 40%, 50%, 60%, 70%, 80%, and 90% maxHRR. Participants' maximal heart rate was established using an age-based calculation (207 – 0.7 x age; Gellish et al., 2007). In calculating the exercise heart rate for each of the six work intensities, HRR was established by application of the Karvonen formula (Karvonen, Kentala, & Mustala, 1957). This enabled the standardisation of work intensity across participants. Each participant was required to sit quietly for 5 min and then a resting heart rate was recorded. Subsequently, each participant was habituated to the treadmill ergometry task. Each participant spent ~20 min on the treadmill ergometer during the habituation trial, during which time the experimental protocol was explained to them. The in-task and post-task measures were explained to participants and they were afforded an opportunity to ask questions.

3.2.2.5 Experimental trial. Participants were exposed to 30 conditions over six visits to the laboratory (five conditions per visit). Conditions were administered in a partially-counterbalanced order to ensure that the same track was not heard twice in a single visit and that the potential for order effects was minimised. On each occasion, participants walked/ran at a combination of the intensities: 40%, 50%, 60%, 70%, 80%, and 90% maxHRR while being exposed to the four tempo and no-music control conditions.

Participants were requested to follow identical patterns of activity (no other vigorous physical activity permitted) and diet on the day of each testing session. Further, they were requested not to eat within 2 hr prior to testing or consume caffeine within 12 hr and each participant engaged in the trial individually. The participant would wear a heart rate monitor (chest strap) and the receiver would be held by the researcher. In order to negate the influence of extraneous visual stimuli, the participant was requested to look straight ahead at a blank wall and the area immediately surrounding the treadmill was screened off as not to offer any visual stimulus to the participant.

Following a 5-min warm-up at a speed of 5 kph with no music, the experimenter selected the appropriate exercise intensity by adjusting the velocity of the treadmill and altering the gradient; there was a 1% gradient increase for every 0.5 kph increase in velocity. Once participants had reached a steady state at the prescribed exercise intensity, they heard and responded to four music tempo conditions and a no-music control, each of 2 min duration. The participants were informed 5 s before the start of each condition that the condition would begin shortly. This 5 s notice served two purposes: firstly, to ensure the participant was ready for the music to begin and would not be startled by the onset of the music; secondly, to make the participant aware that the no-music control condition will begin as to avoid any confusion by a long period of silence.

Fifteen seconds before the end of each excerpt, participants were asked to rate their preference for the musical excerpt and administered the Feeling Scale and Felt Arousal Scale. Participants dismounted the treadmill at the end of each condition and sat at a nearby desk. The participant would then complete the state attention item, S FSS-2, and IMI items. Thereafter, a 60 s filler was employed (Concentration Grid; Harris & Harris, 1984) in order to avoid any potential carry-over effect between experimental conditions. The recovery period between each short bout of exercise was ~4 min. Each participant performed a 5-min cool-down at the end of each testing session, which lasted for ~45 min. Female participants were asked to report the length of time (days) since menstruation to enable calculation of menstrual cycle stage. This information was to be used to help schedule future sessions to minimise the effect that menstrual cycle stage can have on physiological and psychological indices (see Lentz, 2012).

3.2.2.6 Post-test interview. In order to corroborate the experimental findings with qualitative data and incorporate the viewpoints of the experimental participants, a subsample (*n* = 8) with an even split of women and men was selected randomly and interviewed for a period of ~15 min. The hypothesised psychological benefits in regard to optimal music tempo exposure were expected to be corroborated, to a degree, by the interview data. A schedule of open-ended questions was used (see Appendix D) that allowed each participant's perspectives to emerge. Examples of questions include "Did the music have any effects at all on how you were feeling?" and "Did you notice any changes in the music other than the fact you were listening to four different tracks and sometimes there was silence?" Follow-up questions (probes) were used to enhance the richness of the interview and to reveal the precise meaning given by each participant to their experiences during testing (see Marshall & Rossman, 2011, pp. 145–146). The interviews were recorded digitally using a smartphone (iPhone 4) and transcribed verbatim prior to analysis.

3.2.3 Data Analysis

Using PASW Statistics 18, numerical data were screened for univariate and multivariate outliers. Following checks to ensure that the data were suitable for parametric analysis, mixed-model 6 x 5 x 2 (Exercise Intensity x Music Tempo x Gender) MANOVA and ANOVAs were applied to all dependent variables except the tempo preference item, which was analyzed using a 6 x 4 x 2 ANOVA (Exercise Intensity x Music Tempo x Gender). Following appropriate reconfiguration of the data, significance values ($p < .05$) relating to linear, quadratic, cubic, and quartic relationships were examined using a oneway ANOVA. The qualitative data collected after the experimental trials were subjected to inductive content analysis (see Marshall & Rossman, 2011). Specifically, statements were grouped together into thematic categories and then further grouped until a point of redundancy had been reached.

3.3 Results

Checks for outliers indicated that there were five univariate outliers ($z > \pm$ 3.29) and these were assigned a raw score that was within one unit of the next most extreme score in the distribution (Tabachnick & Fidell, 2007, p. 77). Tests of the distributional properties of the data in each cell of each analysis ($k = 612$) revealed 38 major violations ($z > \pm$ 3.29; 6.2% of cells). Specifically, the preference scores demonstrated a mild negative skew, therefore a reflect and square root transformation to this variable was applied, which served to normalise it. The IMI PT variable demonstrated mild positive skew; therefore a square root transformation was applied which served to normalise it (Tabachnick & Fidell, pp. 86–88).

Mauchly's test indicated 19 instances in which the sphericity assumption was violated. Mauchly's test indicated a violation of the sphericity assumption for the Intensity x Music Tempo interaction for the Tempo Preference item scores, Mauchly's $W = .00$, $\varepsilon = .43$, $p < .001$, the intensity main effect, Mauchly's $W = .18$, $\varepsilon = .54$, $p = .007$. Mauchly's test indicated a violation of the sphericity assumption for the Intensity x Music Tempo for the Feeling Scale scores, Mauchly's $W = .00$, $\varepsilon = .37$, $p = .049$, the tempo main effect, Mauchly's $W = .272$, $\varepsilon = .72$, $p = .005$, the intensity main effect, Mauchly's $W = .05$, $\varepsilon = .46$, $p < .001$. Mauchly's test indicated a violation of the sphericity assumption for the Intensity x Music Tempo for the Arousal Scale scores, Mauchly's $W = .00$, $\varepsilon = .42$, $p = .001$, the intensity main effect, Mauchly's $W = .11$, $\varepsilon = .46$, $p < .001$.

Mauchly's test indicated a violation of the sphericity assumption for the Intensity x Music Tempo interaction for the S FSS-2 scores, Mauchly's $W = .00$, $\varepsilon = .41$, $p = .003$, the intensity main effect, Mauchly's $W = .12$, $\varepsilon = .59$, $p < .001$, and the tempo main effect, Mauchly's $W = .64$, $\varepsilon = .46$, $p < .001$. Mauchly's test indicated a violation of the sphericity assumption for the Intensity x Music Tempo interaction for the IMI Pressure-Tension scores, Mauchly's $W = .00$, $\varepsilon = .45$, $p < .001$, the intensity main effect, Mauchly's $W = .13$, $\varepsilon = .51$, $p = .001$, the tempo main effect, Mauchly's $W = .35$, $\varepsilon = .69$, $p = .022$. Mauchly's test indicated a violation of the sphericity assumption for the Intensity x Music Tempo interaction for the IMI Interest-Enjoyment scores, Mauchly's $W = .00$, $\varepsilon = .44$, $p < .001$, the intensity main effect, Mauchly's $W = .02$, $\varepsilon = .39$, $p < .001$, the tempo main effect, Mauchly's $W = .28$, $\varepsilon = .60$, $p < .001$. Mauchly's test indicated a violation of the sphericity assumption for the Intensity x Music Tempo interaction for the attentional focus item, Mauchly's $W = .00$, $\varepsilon = .40$, $p < .001$, the intensity main effect, Mauchly's $W = .07$, $\varepsilon = .43$, $p < .001$, the tempo main effect, Mauchly's $W = .11$, $\varepsilon = .45$, $p < .001$. Greenhouse-Geisser adjustments were applied to the corresponding F tests. The diagnostic tests indicated that assumptions underlying a two- and threeway mixed-model MANOVA and ANOVA, and oneway ANOVA were satisfactorily met.

3.3.1 Interaction Effects

3.3.1.1 Tempo preference. The higher-order interaction of Exercise Intensity x Music Tempo x Gender was nonsignificant, as were the twoway interactions of Exercise Intensity x Gender, Music Tempo x Gender, and Exercise Intensity x Music Tempo (see Table 3.2 and Table 3.3). In relation to H_1, the Exercise Intensity x Music Tempo interaction did not yield significant ($p > .05$) quartic or cubic trends but did exhibit significant quadratic, $F(1, 504) = 4.32$, $p = .038$, and linear, $F(1, 504) = 5.46$, $p = .020$, trends.

Three visualisations have been included to facilitate interpretation of the present findings: Figure 3.3 depicts mean tempo-preference ratings across exercise intensities and Figure 3.4 illustrates the mean and standard error of participants' most preferred tempo at each exercise intensity. Although an imperfect representation of music tempo preference, Figure 3.4 enables a better depiction of the exercise HR-music tempo preference relationship and facilitates direct comparison with Karageorghis et al.'s (2011) data that were captured using a broadly comparable cycle ergometer protocol (Figure 3.5).

Table 3.2

Inferential Statistics Results for all Dependent Variables

	Pillai's trace	*F*	*df*	*p*	η_p^2
Interaction effects					
Tempo preference					
Exercise intensity x music tempo x gender		.73	15, 300	.752	.03
Exercise intensity x gender		.60	5, 300	.702	.03
Music tempo x gender		1.01	3, 300	.393	.05
Exercise intensity x music tempo		1.86	6.43, 128.65	.088	.09
In-task affect					
Exercise intensity x music tempo x gender	.10	1.01	40, 800	.455	.05
Exercise intensity x gender	.09	.88	10, 200	.549	.04
Music tempo x gender	.24	2.78	8, 160	.007	.12
Exercise intensity x music tempo	.13	1.35	40, 800	.075	.06
State attention					
Exercise intensity x music tempo x gender		.91	20, 400	.575	.04
Exercise intensity x gender		1.07	5, 400	.383	.05
Music tempo x gender		.54	4, 400	.711	.03
Exercise intensity x music tempo		.849	8.08, 161.64	.562	.04
Motivation variables					
Exercise intensity x music tempo x gender	.15	1.01	60, 1200	.310	.05
Exercise intensity x gender	.13	.93	15, 300	.531	.04
Music tempo x gender	.39	3.02	12, 240	.001	.13
Exercise intensity x music tempo	.16	1.15	60, 1200	.206	.05
Main effects					
Tempo preference					
Exercise intensity		6.17	2.70, 54.11	.002	.24
Condition		6.49	3, 60	.001	.24
Gender		7.57	1, 20	.012	.27
In-task affect					
Exercise intensity	.87	15.36	10, 200	< .001	.43
Condition	.68	10.37	8, 160	< .001	.34
Gender	.11	1.20	2, 19	.324	.11
State attention					
Exercise intensity		54.29	2.16, 43.14	< .001	.73
Condition		6.60	1.80, 35.97	.006	.24
Gender		.20	1, 20	.656	.10
Motivation variables					
Exercise Intensity	.81	7.35	15, 300	< .001	.27
Condition	.64	5.44	12, 240	< .001	.21
Gender	.07	.46	3, 18	.717	.07

Table 3.3

Descriptive Statistics for Music Preference Scores Across Six Exercise Intensities

	Music Tempi							
	Slow		Medium		Fast		Very fast	
Exercise intensity	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
40% maxHRR	5.91	2.04	7.91	1.24	6.23	2.15	6.23	2.21
50% maxHRR	6.09	2.47	7.55	1.78	6.68	2.16	6.32	2.18
60% maxHRR	6.59	2.06	7.32	1.36	7.27	1.48	6.32	2.08
70% maxHRR	5.82	2.46	7.68	1.18	7.64	1.19	6.41	1.30
80% maxHRR	5.59	2.25	6.73	1.48	6.82	1.80	5.55	2.08
90% maxHRR	5.05	1.92	6.36	2.10	6.41	1.75	6.18	1.64

Exercise intensity	*M*	*SD*	Music tempo	*M*	*SD*	Gender	*M*	*SD*
40% maxHRR	6.57	2.12	Slow	5.84	2.27	Male	6.00	2.10
50% maxHRR	6.66	2.24	Medium	7.26	1.66	Female	7.05	1.85
60% maxHRR	6.88	1.84	Fast	6.91	1.86			
70% maxHRR	6.89	1.82	Very fast	6.23	1.97			
80% maxHRR	6.17	2.03						
90% maxHRR	6.00	1.95						

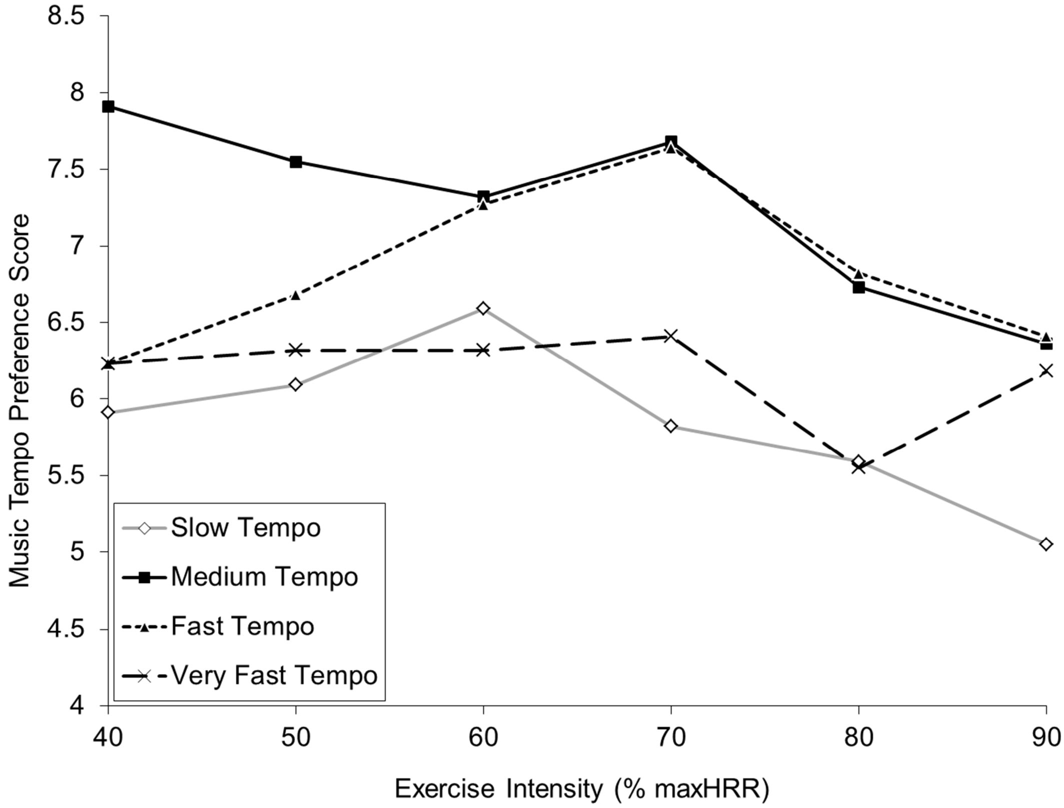

Figure 3.3. Trendlines for music tempo preference ratings across exercise intensities.

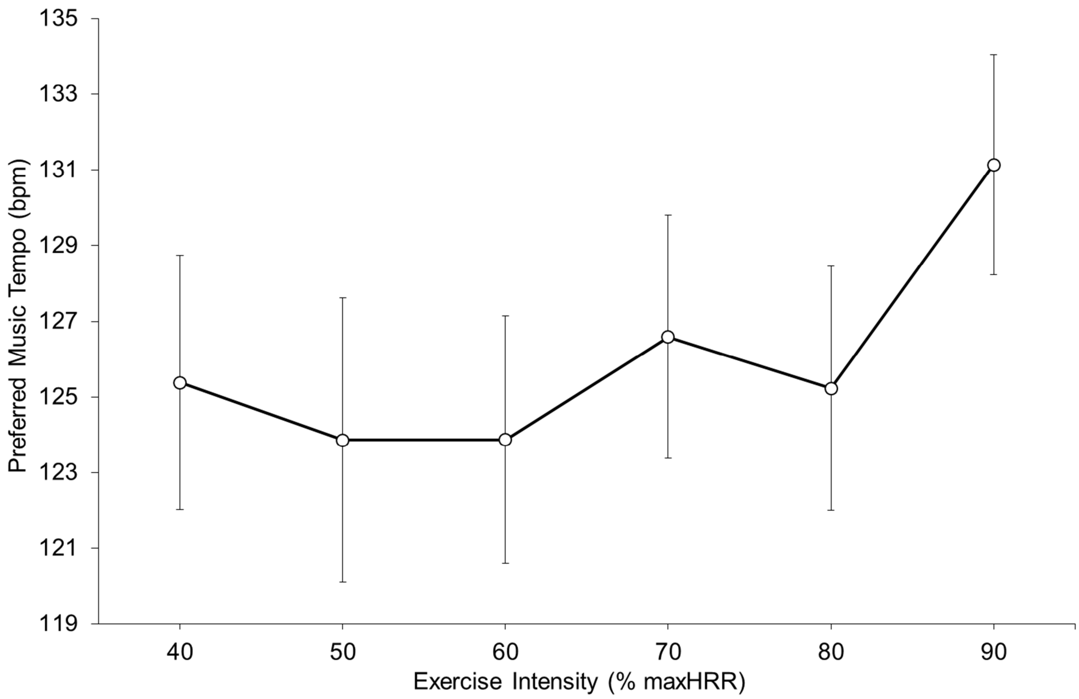

Figure 3.4. Observed relationship between exercise heart rate and music-tempo preference. The plotted scores are means of participants' most preferred tempi at each exercise intensity with standard error bars.

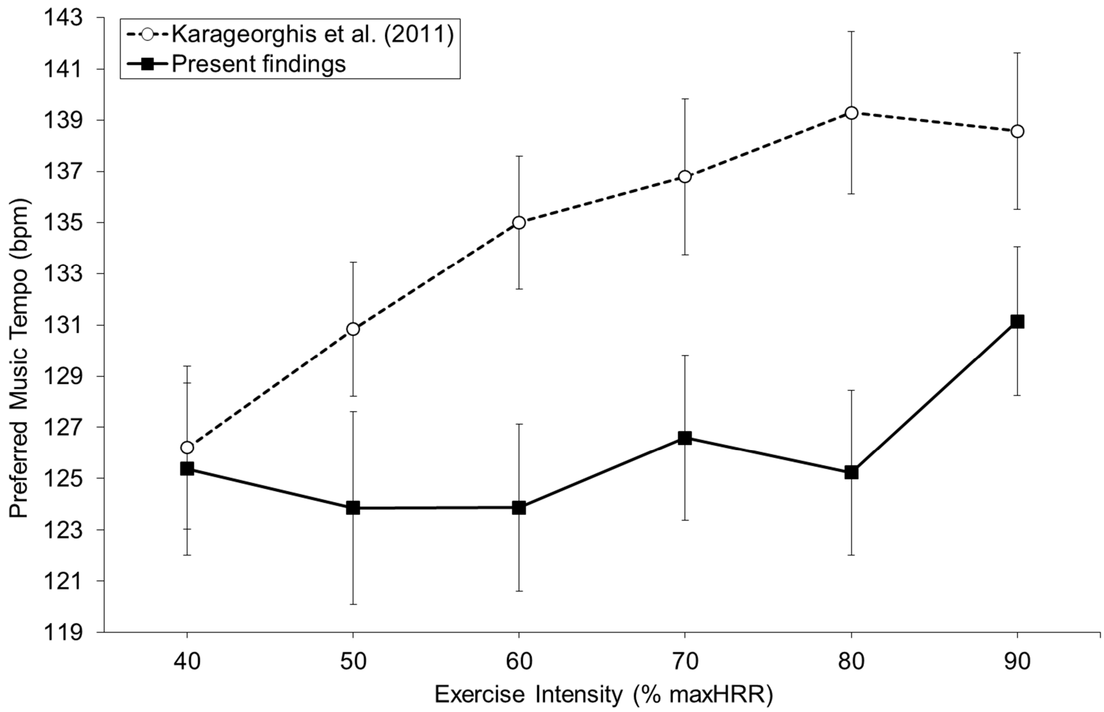

Figure 3.5. Comparison of the observed relationship between exercise heart rate and music-tempo preference from Karageorghis et al. (2011) and the present study.

3.3.1.2 In-task affect. The in-task affective responses (Feeling Scale and Felt Arousal Scale) higher-order interaction of Exercise Intensity x Music Tempo x Gender was nonsignificant, as was the twoway interaction of Exercise Intensity x Gender (see Table 3). In relation to H_3, the Exercise Intensity x Music Tempo interaction was also nonsignificant (see Table 3.2). In relation to H_4, there was a significant twoway interaction of Music Tempo x Gender, which was associated with a moderate effect ($\eta_p^2 = .12$). Step-down *F* tests indicated a significant interaction for affective valence, $F(4, 1) = 2.66$, $p = .038$, $\eta_p^2 = .12$, and perceived activation, $F(4, 1) = 4.49$, $p = .003$, $\eta_p^2 = .18$. An inspection of means and standard errors indicated that affective valence scores for male participants were significantly ($p < .05$) lower during the no-music control condition when compared against medium, fast, and very fast tempi conditions, and lower for slow-tempo when compared against medium-tempo music (see Figure 3.6).

Scores for female participants were significantly lower during no-music control condition when compared against all experimental conditions, and lower when slow tempi were compared against medium tempi ($p < .05$; see Figure 3.6). A similar examination for perceived activation showed that scores for male participants were significantly lower during the no-music control when compared against slow, medium, and fast tempi conditions ($p < .05$). Scores for female participants were significantly lower for the no-music control when compared against all experimental conditions ($p < .05$). Scores were also significantly lower in the slow-tempo condition when compared to the medium- and fast-tempo conditions ($p < .05$).

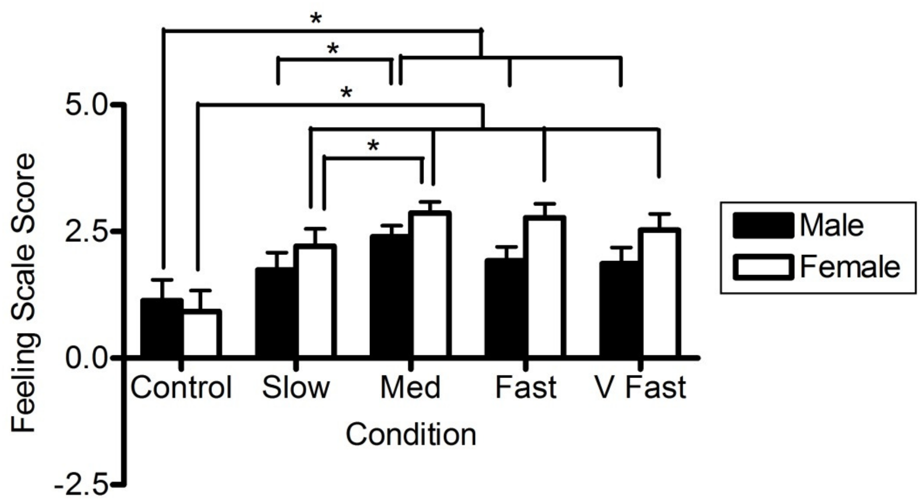

Figure 3.6. Music Tempo x Sex interaction effect ($p = .038$) for affective valence including pairwise comparisons. Error bars represent standard errors. * $p < .05$.

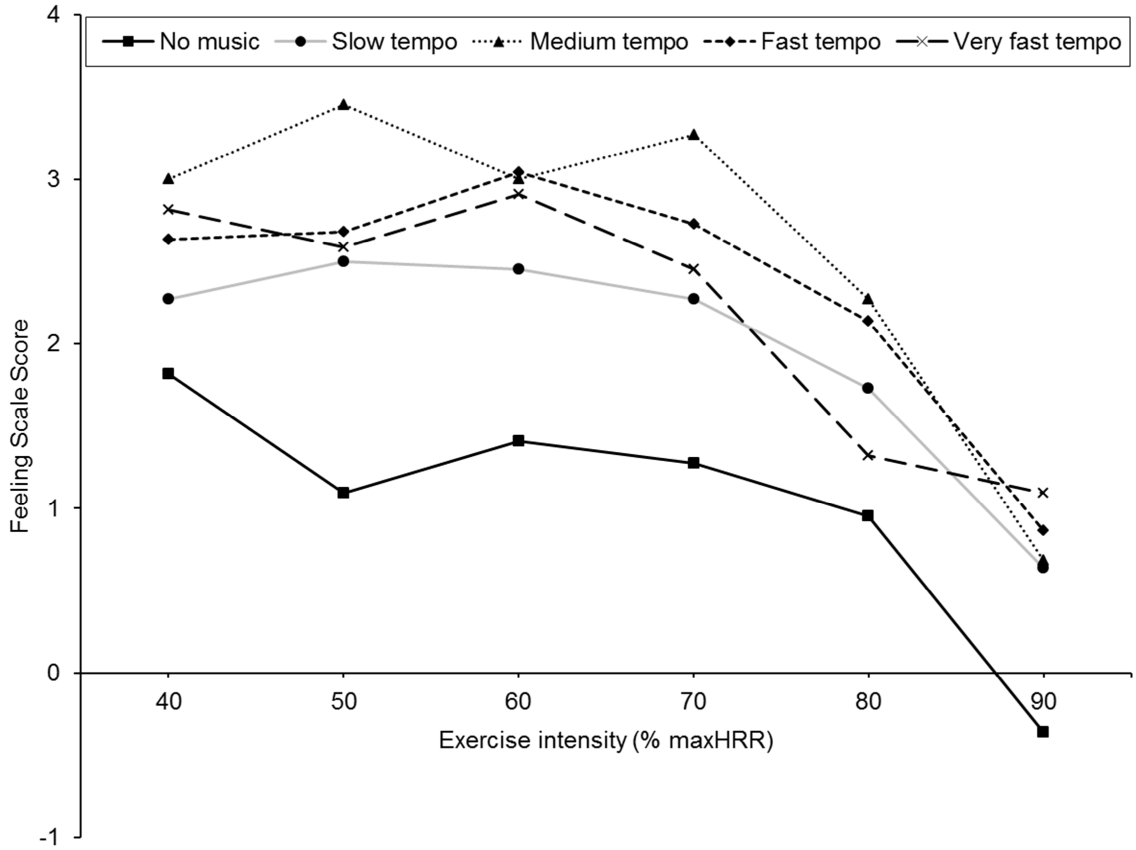

Figure 3.7. The nonsignificant Exercise Intensity x Music Tempo interaction ($p > .05$) effect for affective valence.

3.3.1.3 State attention. The state attention higher-order interaction of Exercise Intensity x Music Tempo x Gender was nonsignificant, as were the twoway interactions of Exercise Intensity x Gender, and Music Tempo x Gender (see Table 3.2). In relation to H_2, the Exercise Intensity x Music Tempo interaction was also nonsignificant (see Table 3.2).

3.3.1.4 Motivation variables. The higher-order interaction for post-task motivation variables (S FSS-2, IMI IE, and IMI PT) of Exercise Intensity x Music Tempo x Gender was nonsignificant, as was the twoway interaction of Exercise Intensity x Gender (see Table 3.2). In relation to H_3, the Exercise Intensity x Music Tempo interaction was also nonsignificant (see Table 3.2). In relation to H_4, there was a significant twoway interaction of Music Tempo x Gender associated with a moderate-to-large effect size (see Table 3.2). Step-down *F* tests indicated a significant interaction for IMI IE, $F(4, 1) = 9.15$, $p < .001$, $\eta_p^2 = .31$, and flow, $F(4, 1) = 5.38$, $p = .001$, $\eta_p^2 = .21$. An examination of means and standard errors indicated that IMI IE scores for male participants were significantly ($p < .05$) lower for the no-music control when compared to the medium-tempo condition.

Scores for female participants were significantly ($p < .05$) lower in the no-music control when compared against all experimental conditions, lower for slow vs. medium, and for slow vs. fast tempi. A similar examination for flow showed that scores for male participants were significantly ($p < .05$) lower in the no-music control compared to medium and fast tempi, lower for slow-tempo music compared to medium-tempo music, and lower for slow- and fast- tempo music ($p < .05$). Scores for female participants were significantly ($p < .05$) lower for the no-music control when compared to the experimental conditions.

3.3.2 Main Effects

3.3.2.1 Tempo preference. There was a significant main effect for exercise intensity ($p < .01$; see Table 3.2), with pairwise comparisons indicating that the 40, 50, 60, 70% maxHRR intensities all yielded significantly ($p < .05$) higher scores when compared to 90% maxHRR (see Figure 3.8). Further, the 50, 60, 70% maxHRR intensities all yielded significantly ($p < .05$) higher scores when compared to 80% maxHRR (see Figure 3.8). There was also a significant main effect for music tempo ($p < .001$), with pairwise comparisons indicating significantly ($p < .05$) lower scores for slow tempi when compared to medium- and fast-tempo conditions (see Table 3.2 and Figure 3.9). Scores for medium-tempo were significantly ($p < .05$) higher when compared to very fast-tempo music, as were scores for fast-tempo when compared to very fast-tempo music (see Figure 3.9). In relation to H_4, there was a main effect of gender indicating that women had higher preference scores than men. Each of the significant main effects was associated with a large effect size (see Table 3.2). Descriptive statistics are displayed in Table 3.3.

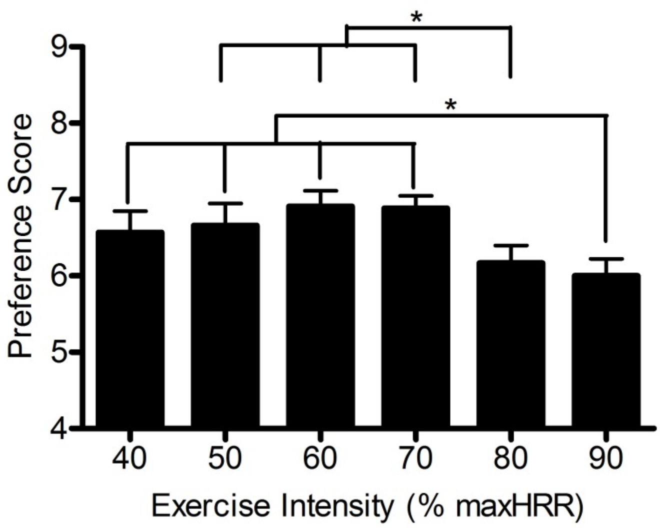

Figure 3.8. Main effect of tempo preference scores for exercise intensity ($p = .002$). Error bars represent standard errors. * $p < .05$.

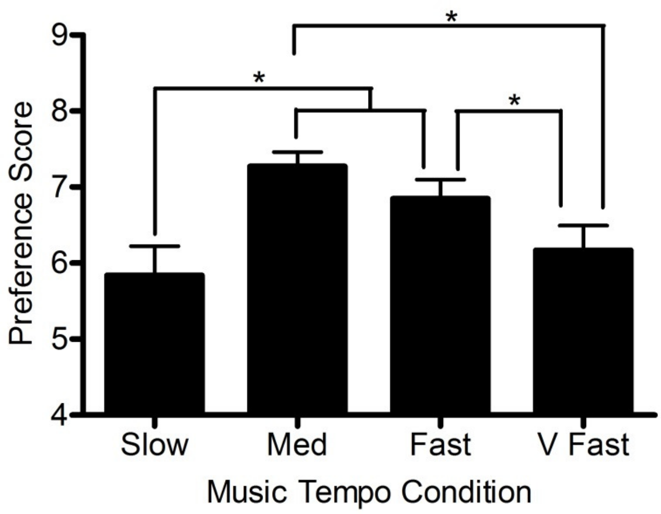

Figure 3.9. Main effect of tempo preference scores for condition ($p = .001$). Error bars represent standard errors. * $p < .05$.

3.3.2.2 In-task affect. There was a significant main effect for exercise intensity ($p < .001$; see Table 3.2). Step-down F tests exhibited significant differences for both variables (affective valence and perceived activation) that were associated with large effect sizes: affective valence, $F(2.29, 45.77) = 20.77$, $p < .001$, $\eta_p^2 = .51$, and perceived activation, $F(2.32, 46.35) = 25.49$, $p < .001$, $\eta_p^2 = .56$. Pairwise comparisons for affective valence indicated significantly ($p < .001$) higher scores for the 40, 50, 60, 70, and 80% maxHRR intensities when compared with 90% maxHRR, and scores for the 40, 50, 60, 70% maxHRR intensities were significantly ($p < .05$) higher compared with 80% maxHRR (see Table 3.4 and Figure 3.10).

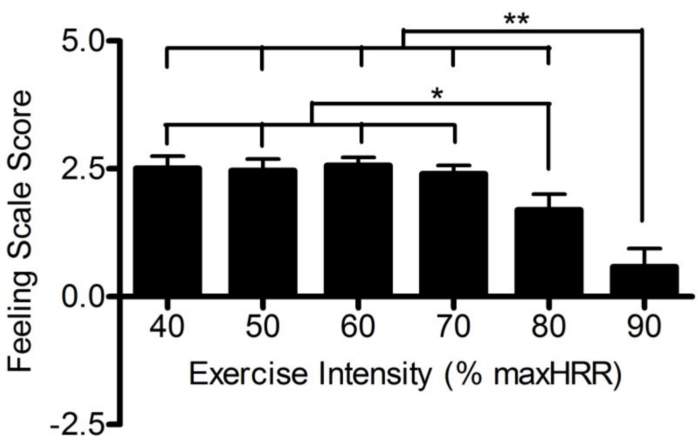

Figure 3.10. Main effect of affective valence scores for exercise intensity ($p < .001$). Error bars represent standard errors. * $p < .05$; ** $p < .001$.

There was also a significant main effect for music tempo (see Table 3.2), with step-down *F* tests indicating that both variables exhibited significant differences that were associated with large effect sizes: affective valence, $F(2.88, 57.57) = 24.62$, $p < .001$, $\eta_p^2 = .55$ and perceived activation, $F(4, 80) = 20.87$, $p < .001$, $\eta_p^2 = .51$.

Pairwise comparisons indicated significantly ($p < .001$) lower affective valence scores during the no-music control when compared to the experimental conditions. There were also significantly ($p < .05$) higher scores with the medium-tempo condition when compared to the other three tempi (see Figure 3.11). Pairwise comparisons for perceived activation indicated that the no-music control was significantly ($p < .001$) less arousing than the four experimental conditions. In addition, there were significantly ($p < .05$) higher scores with medium tempo when compared to slow tempo, and between medium and very fast tempi. Moreover, scores were significantly ($p = .039$) higher in response to fast-tempo music when compared to very fast-tempo music. Descriptive statistics are presented in Table 3.4.

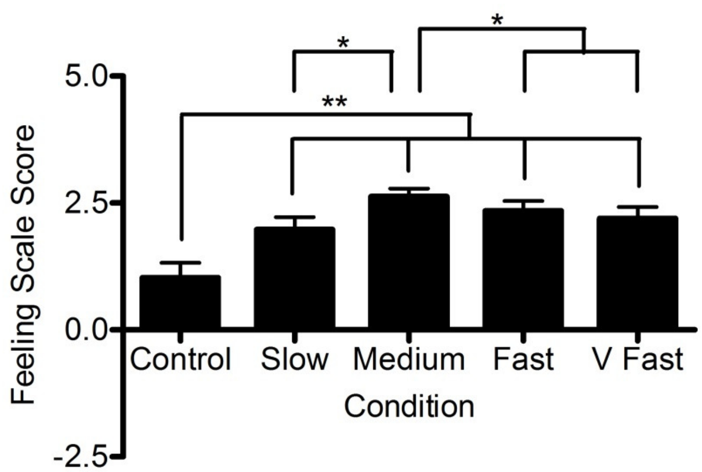

Figure 3.11. Main effect of affective valence scores for condition ($p < .001$). Error bars represent standard errors. * $p < .05$; ** $p < .001$.

3.3.2.3 State attention. There was a significant main effect for exercise intensity that was associated with a large effect (see Table 3.2). Pairwise comparisons indicated that all exercise intensities differed from each other significantly ($p < .05$) with greater amounts of associative thoughts at each subsequent exercise intensity from 40% maxHRR through to 90% maxHRR. There was also a main effect for music tempo, with pairwise comparisons indicating significantly ($p < .05$) greater amounts of associative thoughts during the no-music control when compared against the experimental conditions. Figure 3.12 shows data from the no-music control condition plotted with data from fast-tempo music condition.

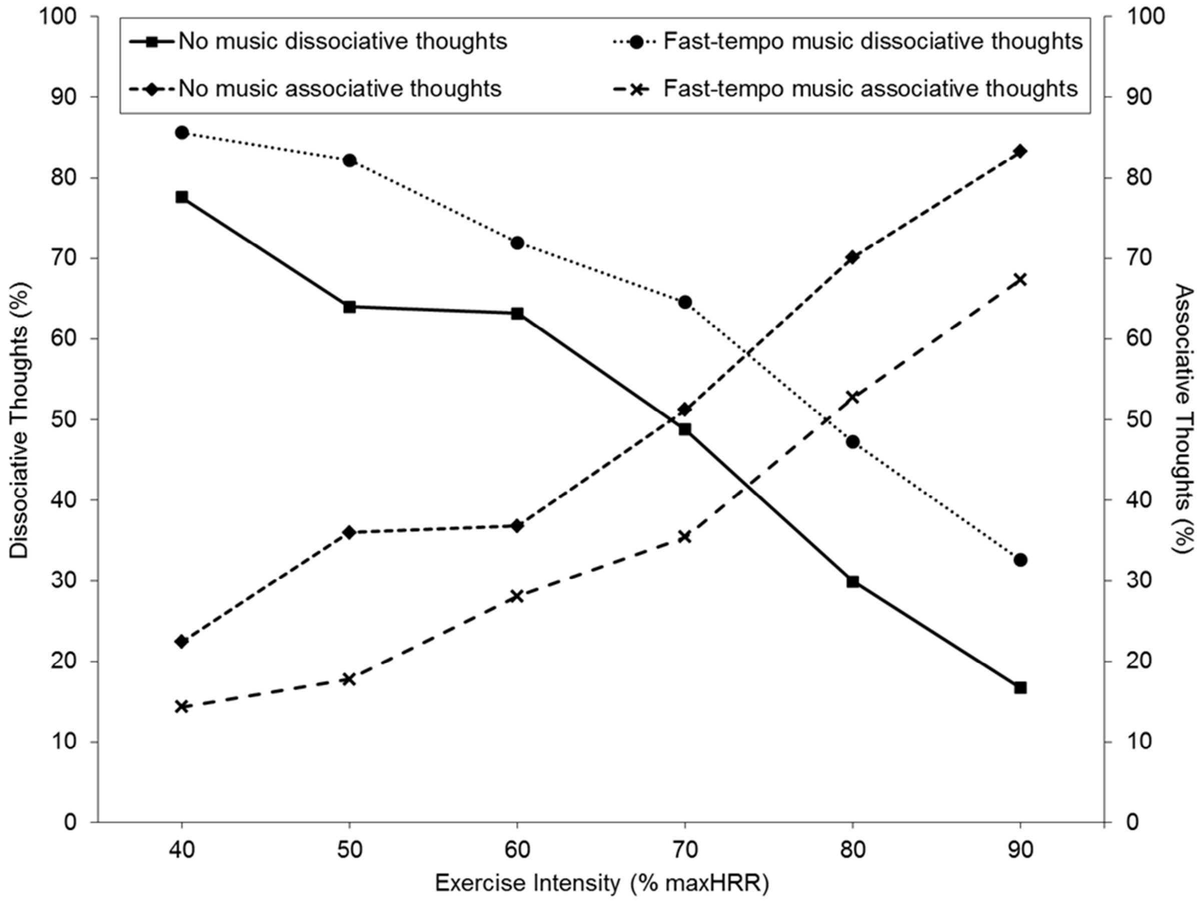

Figure 3.12. Comparison of percentage of dissociative and associative thoughts across all exercise intensities between no-music control and fast-tempo music conditions.

3.3.2.4 Motivation variables. There was a significant main effect for the motivation variables that was associated with a large effect (see Table 3.2). Step-down *F* tests indicated that only IMI PT exhibited significant differences, $F(2.55, 51.01) = 37.50$, $p < .001$, $\eta_p^2 = .65$. Pairwise comparisons showed that IMI PT scores at 40% maxHRR intensity were significantly ($p < .05$) lower than all other intensities. Scores at 50% maxHRR were also lower when compared against the intensities from 60–90% maxHRR ($p < .05$). Also, IMI PT scores were significantly ($p < .05$) lower at 60% maxHRR when compared to both 80 and 90% maxHRR, between 70% maxHRR and both 80 and 90% maxHRR, and between 80 and 90% maxHRR.

There was a main effect for music tempo that was associated with a large effect (see Table 3.2). Step-down *F* tests indicated that all three motivation variables exhibited significant differences, flow: $F(1.82, 36.41) = 7.78$, $p = .002$, $\eta_p^2 = .28$, IE: $F(2.40, 47.97) = 28.34$, $p < .001$, $\eta_p^2 = .59$, and PT: $F(2.77, 55.46) = 5.77$, $p = .002$, $\eta_p^2 = .22$. Follow-up pairwise comparisons for flow indicated significantly ($p < .05$) lower scores for the no-music control when compared to the four experimental conditions. There were also significantly ($p < .05$) lower scores for slow tempo when compared with both medium and fast tempi, and between fast-tempo and very fast-tempo music.

Pairwise comparisons for IMI IE indicated significantly ($p < .001$) lower scores for the no-music control when compared against the experimental conditions. There were also significantly ($p < .05$) lower scores with slow-tempo music when compared with both medium and fast tempi, and fast-tempo music led to significantly ($p < .05$) higher scores when compared with very fast-tempo music. Pairwise comparisons for IMI PT showed significantly ($p < .05$) higher scores for the no-music control condition when compared to the four experimental conditions. Descriptive statistics are displayed in Table 3.4.

Table 3.4

Descriptive Statistics for Each Dependent Variable Across Six Exercise Intensities

		Feeling Scale		Felt Arousal		State Attention		S FSS-2		IMI IE		IMI PT	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
40% max HRR	N	1.82	1.71	2.36	0.66	77.59	23.56	32.32	3.51	3.36	1.09	1.70	0.82
	S	2.27	1.42	3.09	0.92	85.05	12.69	33.45	4.68	4.00	1.23	1.44	0.50
	M	3.00	1.20	3.45	1.01	86.25	19.16	36.05	4.38	4.78	0.90	1.26	0.42
	F	2.64	1.26	3.14	0.99	85.64	16.83	34.27	4.00	4.27	1.08	1.35	0.47
	VF	2.82	1.47	3.09	1.06	82.68	15.17	35.09	4.40	4.41	1.17	1.48	0.56
50% max HRR	N	1.09	1.63	2.59	0.80	64.02	33.88	32.32	4.66	3.21	0.98	1.95	0.65
	S	2.50	1.60	3.32	0.99	76.27	19.14	33.91	4.26	4.13	0.97	1.77	0.84
	M	3.45	0.96	3.77	1.07	79.11	20.03	34.86	4.06	4.70	1.04	1.55	0.66
	F	2.68	1.64	3.73	1.08	82.25	22.49	35.68	4.89	4.66	1.25	1.70	0.90
	VF	2.59	1.44	3.14	0.71	77.34	21.05	33.86	4.96	4.36	1.06	1.56	0.63
60% max HRR	N	1.41	1.79	2.77	0.87	63.18	29.63	32.77	4.91	3.49	1.12	1.99	0.92
	S	2.45	1.34	3.73	1.03	72.98	20.02	34.77	4.86	4.64	0.90	1.87	0.63
	M	3.00	1.35	4.05	0.84	67.91	21.38	34.86	4.31	4.79	0.67	1.92	0.95
	F	3.05	0.95	3.86	0.94	71.95	23.11	35.50	4.21	4.85	0.96	1.69	0.62
	VF	2.91	1.15	3.68	0.95	70.43	19.84	34.86	4.30	4.72	0.90	1.63	0.58

Note. N = No music condition, S = Slow tempo condition, M = Medium tempo condition, F = Fast tempo condition, VF = Very fast tempo condition.

(continued)

		Feeling Scale		Felt Arousal		State Attention		S FSS-2		IMI IE		IMI PT	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
70%	N	1.27	1.52	3.18	1.10	48.80	29.36	31.64	5.37	3.58	1.04	1.96	0.73
max	S	2.27	1.24	3.86	1.04	59.95	27.40	33.95	3.87	4.68	0.71	1.78	0.70
HRR	M	3.27	0.94	4.36	1.05	63.23	24.28	35.18	4.34	5.16	0.84	1.86	0.69
	F	2.73	1.20	4.23	0.87	64.55	21.78	35.36	3.81	5.12	0.98	1.85	0.84
	VF	2.45	1.34	3.77	1.07	65.73	25.60	33.86	4.29	4.65	0.97	1.89	0.78
80%	N	0.95	2.17	3.50	1.06	29.91	25.81	31.91	5.34	3.88	1.12	2.45	0.93
max	S	1.73	1.86	4.05	0.79	54.95	28.04	33.91	4.41	4.58	1.07	1.92	0.74
HRR	M	2.27	1.67	3.95	1.00	53.39	25.03	35.41	4.19	4.79	0.91	2.06	0.75
	F	2.14	1.58	4.09	0.68	47.23	22.75	34.77	4.96	4.79	0.95	1.95	0.73
	VF	1.32	1.91	4.09	0.87	51.45	26.64	33.14	4.64	4.63	0.89	2.15	0.90
90%	N	-0.36	2.13	4.05	1.05	16.68	20.10	31.32	5.38	3.74	1.18	3.10	0.91
max	S	0.64	2.13	4.41	1.01	26.32	22.67	32.86	3.99	4.47	0.94	2.71	1.10
HRR	M	0.68	1.89	4.32	0.72	28.98	25.48	33.23	3.99	4.47	1.07	2.63	1.16
	F	0.86	2.19	4.59	0.85	32.61	27.64	34.95	4.34	4.61	1.04	2.56	0.91
	VF	1.09	1.80	4.36	0.90	32.48	25.12	33.59	4.76	4.54	0.72	2.74	1.03

Note. N = No music condition, S = Slow tempo condition, M = Medium tempo condition, F = Fast tempo condition, VF = Very fast tempo condition.

3.3.3 Inductive Content Analysis

Interviews with a subsample of eight participants were conducted and the subsequent inductive content analysis of their responses is included as a supplement to the quantitative analyses. Participants indicated that the music conditions (regardless of tempo) elicited a broad category of response that is labelled "Enhanced exercise experience" (see Table 3.5). Examining this general dimension in greater depth, the raw data themes revealed benefits that included outcomes listed in Terry and Karageorghis' (2006) conceptual framework of increased arousal and dissociation (first-order themes). Participant 10 highlighted how "At higher intensities the music had more of an effect on me – it made me feel better." Similarly, in relation to arousal, participant 25 stated "So it really made me, like ….up for it." Seven participants passed comment on the dissociative effects of music; typical of these was the following "The music gives you something to concentrate on other than pain." (Participant 10).

A second category emerged labelled "Behavioural responses to music" (see Table 3.5), which embraces raw data themes pertaining to perceived increases in motivation and entrainment to music. In relation to the former, participant 16 revealed "There were a couple of songs that stood out, that kind of made me push it more." In regard to the latter, participant 1 explained "I don't think I was trying to keep in time with the music, I think it just sort of ended up going that way." Participant 13 commented "I think I changed my steps to the beat of the music, because it was easier to run along to it." Moreover, the tempo of the music was relevant to some of the participants with reference to exercise intensity; participant 1 revealed "My preference for the JLo track depended on how quick I was going." The reference to the "JLo" track pertains to the fast-tempo music condition.

Table 3.5

Results of the Inductive Content Analysis

Raw data themes (k = 31)	First-order themes (k = 5)	General dimensions (k = 2)
Enjoyed listening regardless of the intensity	Positive affective state	Enhanced exercise experience
I was pretty happy with the music throughout		
I wasn't worried how tired I was		
I prefer upbeat tracks because you get into it more		
The music gets you going	Arousal	
The music livened me up a little		
Felt a lot more springy		
Felt more distracted	Dissociation	
Takes your mind off the pain		
Low intensities completely distracted		
The music took my mind off running		
I was singing in my head		
The music helped me zone out		
The lyrics stood out		
Concentrating on the lyrics		
When you had no music at the highest intensity it was even worse		
The music makes you forget little niggles		
With the music, it was automatic, I didn't think about doing it		
Push yourself	Increased motivation	Behavioural responses to music
When running was harder the music helped me carry on		
I was not really motivated without music		
You can really get going to *Stronger*		
Words making me go for it		
Music is going to help you most at the highest intensities		
I think I changed my steps with the music	Entrainment	
Linked to how I run		
My experience of the music depended on how quick I was going		
Mismatch in beat and movement		
It was easier to run along with music		
I like to run to the rhythm		
If you're running fast, then Chase and Status helps you go a little bit more		

3.4 Discussion

The main purpose of the present study was to assess the stability of a cubic exercise heart rate-music tempo preference relationship using a different exercise modality to that employed by Karageorghis et al. (2011), while the secondary purpose was to examine a number of psychological outcome variables with reference to this relationship. This secondary purpose represented the most novel aspect of the present study. Figure 3.5 illustrates the present results for tempo preference in comparison with the results of Karageorghis et al. and demonstrates that the exercise heart rate-music tempo preference is not stable across exercise modalities, therefore H_1 is not supported. The standard errors bars in Figure 3.5 also reveal greater variability in music tempo preference during a treadmill task (the present study) at the low-to-moderate exercise intensities when compared to the standard errors in a cycle ergometry task (Karageorghis et al).

The most striking difference between the two plots in Figure 3.5 is that the cubic relationship found by Karageorghis et al. (2011) with cycle ergometer exercise is not evident with treadmill exercise. The present relationship suggests no discernible differences in preference among music tempi at low-to-moderate exercise intensities (40–60% maxHRR), a rise of ~4 bpm from 60–70% maxHRR, a levelling out in tempo preference from 70–80% maxHRR, followed by a sharp rise of ~5 bpm from 80–90% maxHRR. Where there is some similarity between the two studies is that the range of tempi that are preferred across a broad spectrum of exercise intensities is narrow, albeit considerably narrower in treadmill running (123–131 bpm) than in cycle ergometry (125–140 bpm).

Present findings pertaining to the preference for medium-tempo music across all intensities bear resemblance to those of Karageorghis et al. (2006) who showed that participants engaged in a treadmill walking task reported similar scores for medium-tempo music at low-to-moderate intensities with a slight dip in preference in the high-intensity condition (75% maxHRR). Figure 3.3 illustrates how the only meaningful differences in preference were between medium-tempo music and the remaining tempo conditions at 40–50% maxHRR, between both medium- and fast-tempo conditions compared with the remaining conditions at 60–80% maxHRR, and between slow tempo and medium, fast, and very fast tempi at 90% maxHRR. At exercise intensities of 40–80% maxHRR, it appears that music in the very narrow tempo range of 123–127 bpm is optimal (see Figure 3.4). A further similarity with the 2006 paper concerns the Exercise Intensity x Music Tempo interaction which yielded identical effect sizes, of a moderate order, in both studies ($\eta_p^2 = .09$).

3.4.1 Psychological Outcomes

The present study extended previous work (e.g., Karageorghis et al., 2008) through the inclusion of a range of psychological outcomes to gauge whether optimising the music-tempo selection was associated with superior outcomes. When examining the present music preference findings in light of the range of psychological outcome measures, it is evident that, at the highest exercise intensity (90% maxHRR), very fast music elicited the most positive affective responses, whereas at the low intensities, the medium-tempo music had a similar effect (see Table 3.4 and Figure 3.7). There was no discernible trend for perceived activation or flow state, although for state attention it transpired that fast- and very fast-tempo music elicited the lowest levels of association at 90% maxHRR. For the two IMI subscales, it was evident that IE was highest when medium-tempo music was played at intensities 60-80% maxHRR, whereas PT increased as intensity increased, but was not influenced by manipulations of music tempo; it was higher in the no-music control when compared to all music conditions. The IE finding mirrors that of Karageorghis et al. (2008), although they used a singular exercise intensity of 70% maxHRR and administered music programmes comprised of varying tempi. Collectively, the results show that the modest differences in music tempo preference across exercise intensities were not strongly associated with psychological outcomes when there was a match between intensity and music tempo; accordingly, H_3 was also not accepted.

Past work has shown that affective states are more negatively valenced when participants exercise beyond ventilatory threshold (Ekkekakis & Acevedo, 2006), and the present findings suggest that at moderate and high intensities, appropriately-selected music can attenuate such negative feelings. Figure 3.7 visualises the decline in affective valence as exercise intensity increases. Although ventilatory threshold was not assessed in the present study, it can be seen from Figure 3.7 that affective valence declines sharply during high-intensity exercise; however, this decline is ameliorated in all music conditions compared to control. These findings are similar to that of Elliott et al. (2004), Elliott et al. (2005), and Elliott (2007) who found that music conditions enhanced feelings of affect during high-intensity exercise, but the present study advances these findings by demonstrating the pattern of affective responses across a wide range of exercise intensities.

The main effect of intensity on state attention results lends support to extant findings regarding an attentional shift towards associative focus as exercise intensity increases that is accompanied by a shift towards more negative feeling states (e.g., Hutchinson & Tenenbaum, 2007; Lind, Welch, & Ekkekakis, 2009). It is evident that affective valence during the music conditions is more positive than in the no-music condition (see Table 3.4 and Figure 3.7). This finding bears similarity to those of previous experimental studies into the psychological effects of music (e.g., Edworthy & Waring, 2006; Elliott et al., 2005; Hutchinson et al., 2011; Karageorghis et al., 2008). The state attention data shows a difference in the point at which the switch from a predominantly dissociative focus to a predominantly associative focus occurs with music (see Figure 3.12); this switch is evident at ~68% maxHRR in the no-music control whereas it occurs at ~78% maxHRR during the fast-tempo condition. This finding is notable insofar as it demonstrates that appropriately-selected music can extend the range of exercise intensities over which dissociative thoughts take place, and supports H_2. By using a direct measure of attentional focus, the present study is the first to empirically support the notion that music has a dissociative effect. Previous work had inferred the dissociative effects of music but had not employed a direct measure.

Gender differences were not expected to emerge; nonetheless, the results revealed a series of significant Music Tempo x Gender interactions among the psychological outcome measures that led to the rejection of H_4. Women appeared to derive greater benefit in terms of affective valence when compared to their male counterparts, as their scores were higher in response to each music tempo condition relative to control. Males only appeared to benefit from the medium, fast, and very fast music tempi relative to control. Feeling Scale scores for women were lower in the control condition compared to men, and women scored higher for all music conditions compared to men (see Figure 3.6). This result indicates that women may be more responsive to motivational music conditions (regardless of tempo) during exercise than men. Women also reported higher perceived activation in response to all tempo conditions when compared to control, whereas males reported higher perceived activation in response to slow, medium, and fast conditions only. The benefits in affective valence derived by women in response to musical accompaniment in the present study are somewhat similar to those reported by Karageorghis et al. (2010) in a synchronous circuit training task.

Concerning the variables pertaining to motivation, women reported higher flow state and IE scores than men across all music tempo conditions. The implication is that women are likely to experience a more positive motivational state when exposed to music of any tempo. Allied to this, it was apparent that women reported greater preference overall for music ($M = 7.05$) when compared to men ($M = 6.00$), and this difference was of a greater magnitude than that found by Karageorghis et al. (2011; women $M = 7.14$ vs. men $M = 6.67$). Nonetheless, it should be noted that in both studies the difference in preference between genders did not reach statistical significance ($p > .05$).

A possible reason for the differences reported between the genders (see Figure 3.6) may be found in work regarding emotional responsiveness. Females have been shown to demonstrate greater intensity for emotions that are related to positive and dysphoric experiences (e.g., joy and sadness), whereas males report greater intensity for emotions such as confidence and pride (Brody & Hall, 2009). The instruments used in the present study (e.g., the Feeling Scale) may measure emotions that are felt more intensely by females rather than males. The results may have demonstrated a different pattern if the scales used were more sensitive to the emotions that males feel more intensely (e.g., confidence and pride) than females (e.g., joy and sadness). Additionally, females have been found to adopt a more positive attitude towards music than males (North & Hargreaves, 2008) and this has been attributed to the greater likelihood of females participating in musical activities during their formative years (Crowther & Durkin, 1982).

3.4.2. Present Findings vs. Past Findings

The Karageorghis et al. (2011) study was the first to test the preferences for music tempo across a full range of exercise intensities. The cubic relationship that emerged warranted further investigation to establish its validity and factors such as choice of exercise modality, use of different musical selections, and the influence of the age of the participants were unknown. Thus the 2011 results should be taken to be both preliminarily and tentative in nature. One notable aspect of the 2011 findings was the narrow band of preferred tempi across a range of exercise intensities and this observation was underlined by the present findings. It appears that the range of preferred tempi for asynchronous music in treadmill exercise is only 123–131 bpm, whereas in cycle ergometry it was 125–140 bpm. There are a number of factors that might account for this disparity.

The most prominent difference in methodological terms between the present study and the Karageorghis et al. (2011) study was the choice of exercise modality; the 2011 study employed a nonweight-bearing activity (cycle ergometry) while the present study used a weight-bearing activity (treadmill exercise). Although both are repetitive and relatively simple motoric tasks, the movement pattern, breathing patterns, and neuromuscular demands vary considerably. Also, fatigue perception is far more localised in cycle ergometry (to the quadriceps) than it is in running (whole body; see Koivula & Hassmen, 1998). Despite the fact that in both studies music was applied asynchronously, entrainment theory details the propensity of bodily pulses such as respiration rate and motor patterns to entrain to musical rhythms without conscious effort (Thaut, 2008, pp. 39–59). This was reflected in the interview data which revealed that even though participants were not consciously attempting to entrain their stride rate to the rhythmical qualities of the music, they often found themselves doing so (see Table 3.5). As an illustration of this, Participant 1 revealed that "…if there's a song playing that I like, I like to run to the rhythm."

In the Karageorghis et al. (2011) study, pedal cadence was maintained at 75 rpm and the cycling intensity was augmented via the addition of weights that increased pedal resistance. In the present study, running intensity was augmented through a combination of increases in treadmill belt velocity and gradient. Thus there was greater variability in movement cadence in the present study. Moreover, owing to differences in height among participants, there was also greater between-subject variability in cadence. In terms of motor patterns, cycle ergometry affords fewer degrees of freedom than treadmill running.

Although the salience of music tempo has been repeatedly demonstrated (e.g., Crust, 2008; Edworthy & Waring, 2006), there are, of course, other facets of music that influence response. Chief amongst these are the mode of the music (e.g., major vs. minor; Van Der Zwaag, 2011), the lyrical content (Bishop et al., 2007), and the subdivisions of the beat (Loehr & Palmer, 2009). The mode or harmonic content of the music was not strictly controlled other than via the BMRI-2 ratings, or how the subdivisions of the beat were interpreted. Moreover, all tracks had lyrical content and there were some differences in how participants responded to the lyrical content of the music that became apparent through the qualitative analysis. For example, Participant 16 indicated at the lower exercise intensities, he found it easier to mentally process the lyrical content of the music: "…with the songs playing, I was concentrating on some of the lyrics and things, so I was processing that information."

During the postexperiment interviews, four out of the eight participants stated that they found the lyrical affirmation in Kanye West's *Stronger* (medium-tempo track) to be particularly powerful ("work it harder, make it better, do it faster, makes us stronger"). For instance, Participant 5 commented "…it keeps saying 'Stronger', so you just push yourself." When tempo preference was examined independently of exercise intensity, the track *Stronger* yielded the highest score (M = 7.26) and differed significantly ($p < .05$) from both slow and very fast-tempo music. It also transpired that some participants were unable to correctly place the experimental tracks in order of tempo. Specifically, four of the eight participants in the interviews did not accurately identify the very fast-tempo track as the fastest piece of music.

Beyond the specific components of music (e.g., tempo and melody) that are known to influence responses, personal factors (as acknowledged in conceptual models; Karageorghis et al., 1999; Terry & Karageorghis, 2006) are crucial in terms of determining responses to music in an exercise context. Karageorghis and Priest (2012b) suggested that "personal variables in musical reactivity within the exercise context are currently an underexplored area" (p. 76). The present study sought to control for two significant personal factors that determine responses to music (i.e., age and socio-cultural background), but there is currently a lack of understanding regarding how other factors, such as dominant attentional style, may influence responses to music in an exercise context.

Similar to the findings reported by Karageorghis et al. (2006a, 2011), at the low intensities (40–50% maxHRR) the medium tempo track was preferred. Figure 3.12 demonstrates that there is greater scope for attention to be shifted voluntarily during low-to-moderate intensity exercise; therefore it would have been somewhat easier for participants to process the lyrical content of the music (cf. Rejeski, 1985; Tenenbaum, 2001). At higher intensities, fast-tempo and medium-tempo music is equally preferred (see Figure 3.3), whereas at low intensities, medium-tempo music is preferred. These present results broadly support Berlyne's (1971, p. 70) theoretical proposition and empirical findings (see North & Hargreaves, 2008 for a review) showing that high arousal states should be associated with preferences for fast-tempo music.

Participants appear to require more stimulation through the music at moderate-to-high exercise intensities, and in particular at 90% maxHRR (Figure 3.4). Nonetheless, a strong finding that emerged is that music conditions (i.e., regardless of its tempo) are less preferred at 80–90% maxHRR when compared to low-to-moderate intensities (see Table 3.3) while the ratings for affective valence and associated pattern of differences across exercise intensities matched those for preference almost precisely. Nonetheless, although the trend for affective valence did not reach significance, the medium-, fast-, and very fast-tempo conditions ameliorated the decline in affect that is evident in the no-music condition (see Table 3.4).

3.4.3 Practical Implications

Although this lineage of recent studies has not established a clear exercise heart rate-music tempo preference relationship, the range of preferred tempi in bipedal activities (cycling and walking/running) is much narrower than previously thought (cf. Iwanaga, 1995a, 1995b). In order to optimise tempo selections across a range of exercise intensities, selections in the range 123–140 bpm should be considered. Nonetheless, the present findings show only a weak association between preferred tempo across six exercise intensities and a broad range of psychological outcomes (see Exercise Intensity x Music Tempo effect sizes in Table 3.2). This means that as long as a piece of music is perceived by an exerciser to be motivational, it is likely to have a positive influence on psychological outcomes.

Practitioners should, however, avoid using slow selections (< 100 bpm) for high-intensity activity or very fast selections (> 140 bpm) for low-intensity activity. The weak associations evident in Table 3.2 along with the means in Table 3.3 suggest that incongruence between exercise intensity and music tempo would not optimise psychological outcomes measured in this study.

The findings reinforce the notion that, at the very highest exercise intensities (i.e., 80–90% maxHRR), there is the least potential in absolute terms for participants to derive psychological benefits from music of any tempo (Rejeski, 1985; Tenenbaum, 2001). However, the relative benefits of music vs. no-music conditions at these highest intensities are notable from an applied perspective; for example, at 90% maxHRR there is a mean difference of 1.45 in affective valence scores between the very fast music and no-music conditions (see Table 3.4). What is striking from a public health perspective is that at the moderate-to-high exercise intensities that are associated with cardiorespiratory benefits, the use of music appears to assuage the rapid deterioration of affect and promotes situation-specific motivation.

The present findings indicate that motivational music, regardless of tempo, is likely to promote ~10% more dissociation at moderate-to-high exercise intensities. This is noteworthy as it is at these intensities that the general population can derive significant cardiorespiratory benefits from exercise (Ekkekakis & Acevedo, 2006). An obstacle to exercise adherence for many people is the negative affect that is experienced close to and beyond ventilatory threshold (Hall et al., 2002). The present findings indicate that moderate- and fast-tempo music reduced the number of associative thoughts and had a corresponding positive influence on affective valence. This small influence may be very significant in terms of exercise-related affect and adherence among the general population (e.g., Hall et al.; Williams et al., 2008).

Moreover, the affective benefits of music seem to be particularly pronounced for women, as they reported higher affective valence scores in every music condition relative to control (see Figure 3.6).

3.4.4 Limitations of the Present Study

Participants' responses to music may have been influenced by factors outside of experimental control. For example, independent of tempo/meter, the beat was stronger or more clearly discernible in the slow-, medium-, and fast-tempo conditions than in the very fast-tempo condition. It is very challenging to find music in the very fast-tempo category that is equivalent in terms of strength of beat, idiom, and familiarity relative to other tempo categories. It has been argued recently that there is a biological premise for the fact that most music is composed/recorded close to a tempo of 120 bpm (Schneider, Askew, Abel, & Strūder, 2010). This tempo is allied to a "natural" walking step frequency of 2 Hz and corresponds with the notion of "natural rhythmicity"; for example the preferred spontaneous tempo of finger tapping.

A further issue concerns the lyrical content of the tracks used, which could have been interpreted differently by participants (as suggested by the qualitative data), despite the fact that the tempo and motivational qualities of the music were standardised. Thus a potential limitation is that participants' preference scores may have been influenced by the lyrical content of music (cf. Crust, 2008). One way by which to overcome this limitation is to use a single track and to digitally alter the tempo in order to create the required experimental conditions (e.g., Bishop et al., 2009). Nonetheless, this approach can lead to a further set of limitations insofar as participants are either irritated by repeated exposure to the same track or if it is an already familiar track, engenders a negative response when it is played at nonfamiliar tempi.

Using different tracks in an experimental design presents a challenge when attributing the source of any reported differences across conditions. The music selection process undertaken in the present design attempted to control for key aspects of the tracks (e.g., melody, lyrics, etc.) in order that the effects of tempo would be isolated. However, given the influence that lyrics had in the present study (see the results of the inductive content analysis) and despite attempts to control for this, it is acknowledged that the process of how tracks are selected could be refined further. Additionally, the results go some way towards highlighting the difficulty in disaggregating the effects of a particular aspect of a track (in the present case, tempo) and the effects of the track as a whole.

The influence of music was assessed in a visually sterile environment which does not represent how it is used in vivo. Moreover, given that the participants were physically active undergraduate students, the results cannot necessarily be generalised to the wider population. The inherent problem with replicating the present study with other groups is that unfit/sedentary and older participants might struggle to exercise at the high intensities required to address the research question. The "perfect experiment" is simply not attainable in this domain of scientific endeavour given that when researchers strive to release some of the controls, such as through using participant-selected music or conducting the study with gym users, internal validity is immediately compromised.

3.4.5 Future Directions

Despite the fact that tempo appears to be a strong determinant of music preference, given the information processing demands that are placed by high-intensity exercise in particular (Rejeski, 1985), future research might examine music *complexity* (how predictable it is; see e.g., North & Hargreaves, 2008). Complexity could be coupled with music's affective valence and arousing properties to establish a more sophisticated approach by which to advance this line of research. One possible extension of the present protocol would be to examine the interactive effects of music tempo and intensity (volume) across exercise intensities in a similar vein to past studies (e.g., Copeland & Franks, 1991; Edworthy & Waring, 2006). Moreover, given that the qualitative analysis indicated the lyrical content of music was easier to process at the lower intensities, it would be worthwhile to repeat the present protocol using tracks with lyrical and instrumental versions. Such a study might demonstrate that instrumental music is most appropriate for the highest intensities.

Personal factors are acknowledged as antecedents of music preference (Karageorghis et al., 1999; Terry & Karageorghis, 2006). However, there is scant research exploring the influence of personal factors on the effects of music during exercise. Of the few studies to investigate such effects, Crust and Clough (2006) found some evidence that personality characteristics influence responses to music during physical tasks. Future studies exploring the effects of different personal factors on responses to music during exercise may provide researchers with the ability to more accurately account for the effects of different components of music (e.g., tempo), by taking into account the effects of personal factors (e.g., motivational orientation) that are currently unknown.

Along similar lines, gender differences should be further examined, and given the similar age range/athletic background of participants used in this line of studies, there is a need to extend the work to more diverse groups. Such an approach would allow researchers to gauge the degree to which the present findings generalise to the wider population.

3.5 Conclusions

The cubic trajectory (two points of inflection) reported by Karageorghis et al. (2011) using cycle ergometry was not replicated in the present study using treadmill exercise. Rather a significant ($p < .05$) quadratic relationship emerged, which means that there was just one inflection point in the trendline (at 80% maxHRR; see Figure 3.4). The trendline shows that at the highest exercise intensity (90% maxHRR) participants preferred music at ~131 bpm. The range of preferred tempi for treadmill exercise (123–131 bpm) was narrower than that for cycle ergometry (125–140 bpm). There is only a weak association between optimal selection of music tempo at various exercise intensities and a range of psychological outcomes (e.g., affective valence). The implication of this is that to optimise such outcomes, a tempo range as broad as 100–140 bpm might be considered by practitioners. One of the original contributions of this study is that it shows how asynchronous music reduces the number of associative thoughts at all exercise intensities by ~10%.

Chapter 4: Psychological Characteristics as Predictors of Psychological Responses to Exercise with Music

4.1 Introduction

A significant body of research has established a range of ergogenic, psychological, and psychophysical benefits of music use in sport and exercise settings (see Karageorghis & Priest, 2012a, 2012b). However, the notion that music could be helpful should be seen against early music-and-exercise research. Karageorghis and Terry (1997) identified a number of limitations to earlier work that may have accounted for the often equivocal findings of early research. Karageorghis and his collaborators sought to address previous limitations in the music and exercise research and published a series of conceptual frameworks on which future research can be predicated (Karageorghis et al., 1999; Terry & Karageorghis, 2006). An essential component of such conceptual models are *personal factors*; however the degree to which certain personal factors moderate an individual’s response to music during exercise has not been widely investigated.

Karageorghis et al. (1999) developed a model that focused on the notion of motivational music (see Figure 2.1). Motivational music was defined in terms of both music (internal) and personal (external) factors: “The variables that influence the motivational qualities of the music can be either *internal*, pertaining to factors inherent to the composition of music, or *external*, pertaining to how the individual interprets the music” (p. 2). Internal factors relate to rhythm response and musicality which are thought to determine the energy and mood of the music. These internal factors concern how the music is composed and performed, whereas the external factors relate to how it is interpreted by the listener. External factors are the cultural impact of the music and extra-musical associations. The music and personal factors are exhibited in a hierarchical structure, specifically, rhythm response is deemed the most important, and association the least. Karageorghis et al. demonstrated that the internal factors (music factors) are stronger determinants of responses to a piece of music than external factors (personal factors). Accordingly, the factors are presented in a hierarchical order by their contribution to the motivational qualities of a track.

Crust and Clough (2006) raised concern over the framework and its appropriateness for use with asynchronous music. The framework was developed primarily from data recorded through the synchronous use of music, where the importance of rhythm response may be greater than in the asynchronous use of music. Crust and Clough also suggested that, although personal factors are included within the framework, there is no explicit acknowledgement of personality factors. These authors sought to explore whether reactivity to music in a non-complex motor task is associated with personality traits given that individuals have consistently been shown to differ in sensitivity to affective signals (both positive and negative) based on dimensions of personality. Moreover, that greater knowledge of individual differences in responses to music could be used to maximise the potential benefits of music (e.g., improved mood, enhanced flow state).

The responses to motivational music by the participant's in Crust and Clough's (2006) study were explored using personality correlates as measured by Cattell's 16 Personality Factor Questionnaire. They found significant correlations between response to music and the personality factor *liveliness*, and between specific music factors (e.g., melody and lyrics) and the personality factor *sensitivity*. Crust and Clough suggested that responses to motivational music are subtle and determined by both musical factors and personal factors, with a potential interaction between the two.

In the most recent conceptual framework, Terry and Karageorghis (2006; see Figure 2.2) postulated a greater list of benefits that would be derived from listening to music in a sport and exercise context. This framework saw the addition of personal factors as the entry point for the model and suggested they are the antecedents to the potential benefits derived from music use. However, the personal factors in the original and revised model are lacking further explanation and it appears that the personal factors in the framework relate only to age and socio-cultural background (see Karageorghis & Terry, 1997). The findings of Crust and Clough (2006) provide support for the inclusion of personal factors in the models proposed by Karageorghis and his collaborators, and helped to further describe which specific personal factors may influence a person's reactivity to music during exercise. To re-iterate the criticism by Crust and Clough, there is a lack of acknowledgement for individual differences that may serve as antecedents to the benefits of music in the sport and exercise domain.

Priest and Karageorghis (2008) adopted a qualitative approach, one of only a few studies to adopt such an approach in this research area, and sought to identify the characteristics of music used to accompany exercise. Their findings demonstrated the importance of musical, contextual, and individual factors in determining short and long term outcomes to music use during exercise. Priest and Karageorghis found several individual factors that appeared noteworthy in the relationship between music and exercise. These included attitude to exercise, personality, background, music preference, and familiarity. They discussed attitude to exercise in the context of motivation and offered preliminary evidence that people with differing levels of motivation appear to be represented in the population of people using music during exercise. Alongside personality, they highlighted background (related to cultural background) as an important personal factor when assessing people's responses to music in exercise contexts. These factors, along with the personality factors identified by Crust and Clough (2006), are currently the only personal factors that could be included in conjunction with the conceptual models (Karageorghis et al., 1999; Terry & Karageorghis, 2006).

Previous research examining the differences between male and female responses to music in an exercise context has found sex to be a significant factor (e.g., Crust 2008; Karageorghis et al., 1999; Priest & Karageorghis, 2004). Crust found that women identified the melody of a track to be more important to their enjoyment of music in an exercise context than their male counterparts; men reported associations to sport as important. Studies have also suggested that men and women respond in similar ways to music during exercise (e.g., Karageorghis et al., 2006). The picture of how sex influences the relationship between music and exercise is unclear and the examination of how personal factors influence the potential benefits to the application of music during exercise across the sexes is warranted.

The prominence of personal factors in conceptual frameworks to date indicates their potential importance in the dynamic between music and exercise. Given the relative lack of understanding regarding personal factors (beyond age, socio-cultural background, and some aspects of personality) in the relationship between music and exercise, it is an area that warrants further investigation. North and Hargreaves (2008) provide a comprehensive overview of some of the personal factors that determine musical preferences and taste in social and applied psychology settings. Their body of work discusses several personal factors (e.g., age, sex, and personality) across a range of contexts but there is a lack of empirical research examining these factors when applied to the use of music in an exercise context.

Further, a recent review by Karageorghis and Priest (2012b) highlighted the need to further understand personal variables in musical reactivity within the exercise context. Personal factors such as attentional style and motivational orientation are well researched individual difference factors in the sport and exercise psychology literature (e.g., Tenenbaum & Eklund, 2007; Hagger & Chatzisarantis, 2007; Roberts & Treasure, 2012), but these factors are as yet underexplored in exercise to music settings.

4.1.1 Attention as a Personal Factor

The power of music to capture an individual's attention during exercise is often cited as one of the primary mechanisms by which music is an effective intervention in an exercise context. Terry and Karageorghis (2006) stated that greater levels of dissociation is a benefit of using music during exercise and this claim has since received empirical support (e.g., Dyrlund & Wininger, 2008). The way in which the terms association and dissociation have been defined has varied but original descriptions characterised association as a focus on bodily sensations, specifically respiration, temperature, and muscle fatigue. Dissociation was characterised by a cognitive process of "blocking-out" bodily sensations related to physical effort (Lind et al., 2009).

There is scant research examining the dominant attentional style of individuals and this has been cited as an area that warrants further research (Lind et al., 2009). Karageorghis and Priest (2012b) identified individuals with a dominant attentional style to dissociate as *Dissociators*, and those with a dominant attentional style to associate as *Associators*. A study by Brewer, Van Raalte, and Linder (1996) is one of the few to examine the influence of pre-task attentional focus. Their study explored the relationship between dominant attentional style in a specific context and endurance performance in a mixed-sex group of novice and trained cross-country runners. They employed the Attentional Focus Questionnaire (AFQ; Brewer et al., 1996) to establish dominant attentional style. They found that a pre-task dissociative focus was negatively correlated with performance of a stair-climbing task ($r = -.26$). Conversely, a pre-task associative focus was positively correlated ($r = .37$) with performance. These findings indicated that adopting a specific pre-task attentional focus (association or dissociation) may have an influence on in-task performance.

A clear trend has failed to emerge regarding the effects of attentional focus on performance and psychological outcomes. Several studies (e.g., Clingman & Hilliard, 1990; Tammen, 1996) have identified an associative strategy to be more effective for running and walking performance, whereas other studies (e.g., Masters & Ogles, 1998) had found a dissociative strategy to be more effective for lowering perceived exertion. An important point of consideration is the mixture of competitive status amongst participants (e.g., elite or non-elite). One trend to emerge from these studies was that experienced endurance athletes appeared to benefit from an associative strategy during competition and dissociation was more effective with inexperienced individuals and during training. Context also appears to be a significant factor in attentional focus. In sport and exercise contexts, the use of each style (associative or dissociative) has predominantly been discussed with regard to performance outcomes (e.g., Morgan & Pollock, 1977) but a few studies have explored the associations between attentional style and psychological outcomes (e.g., Russell & Weeks, 1994; Connolly & Janelle, 2003).

Of particular relevance to the present study is the influence that different attentional styles might have on psychological outcomes (e.g., affect) rather than performance outcomes (e.g., amount of repetitions completed). Pennebaker and

Lightner's (1980) study is particularly noteworthy in this regard. Participants exercised at a higher intensity during an external focus condition, but their self-reported fatigue did not increase in line with this increased exercise intensity. Therefore, Pennebaker and Lightner concluded that greater attentional focus directed towards external stimuli resulted in fewer experiences of fatigue and exercise-related symptoms. These findings were later supported by a number of studies (e.g., Padgett & Hill, 1989; Stanley, Pargman, & Tenenbaum, 2007) with a consensus that a dissociative strategy is associated with lower levels of perceived exertion across a number of activities (e.g., stationary cycling, running). A trend does appear to have emerged over a number of studies (e.g., Pennebaker & Lightner; Russell & Weeks, 1994; Schomer, 1987) that shows a dissociative attentional focus results in fewer reports of fatigue and boredom. Connolly and Janelle (2003) examined the effects of attentional strategies on performance and psychophysical measures (i.e., RPE) and found that an associative style seems most beneficial for performance; it also leads to higher levels of RPE. Research into the effects of attentional style on psychological outcomes has primarily examined perceptions of fatigue, whereas other key psychological outcomes (such as affect) have been neglected.

Rhodes, Fiala, and Connor (2009) conducted a review and meta-analysis of affective judgements and physical activity. The principal finding was that interventions that changed affective judgements were scarce despite their potential to affect physical activity. They concluded that music may enhance affective judgements but only if an individual attended to the music. This suggests that a dissociative focus may lead to enhanced affect in an exercise-to-music context. A review by Lind et al. (2009) focused principally on attentional focus and its effects on exertion, affective response, exercise economy and tolerance. It was concluded that a dissociative strategy may be more effective in reducing perceptions of exertion and enhancing affect during low-to-moderate exercise intensities but this effect may diminish during very high intensity exercise. Therefore, it could be suggested that a dissociative attentional style is more likely to lead to positive psychological outcomes such as increase affective valence.

Arousal, or perceived activation, is often measured in tandem with affective valence (e.g., the Circumplex Model of Affect; Russell, 1980). Perceived activation and affective valence are difficult constructs to separate and several measurement instruments designed to measure affective valence have also taken into account perceived activation in their categories (e.g., Positive Affect – Negative Affect Model; Watson, Clarke, & Tellegen, 1988). They are, however, separate constructs and arousal control was listed in Terry and Karageorghis' 2006 conceptual framework. A criticism of the 1999 model (Karageorghis et al., 1999) was that the term *arousal control* was imprecise, as motivational music would heighten arousal in an exercise context and not be used to reduce arousal (Karageorghis & Priest, 2012a). The music used in an exercise-to-music session is designed to be motivational (as described by Karageorghis et al.) and as such should lead to heightened arousal.

4.1.2 Motivation as a Personal Factor

The extent to which a person is motivated to participate in exercise determines how likely they are to initiate and adhere to an exercise programme. Self-determination theory (Deci & Ryan, 1985) is an extensively researched theory that emphasises human needs, motivational processes (e.g., self-regulation), and the social context (Fortier & Kowal, 2007). The theory details three main types of motivation: intrinsic, extrinsic, and amotivation. Intrinsic motivation was initially presented by Deci and Ryan (1985) as a single type of motivation that was defined by participating in activities for the enjoyment and fun of the activity with no discernible reward. Vallerand and his colleagues (Vallerand et al., 1992, 1993) suggested that there were three levels of intrinsic motivation: to know, to accomplish, and to experience stimulation. Vallerand and Rousseau (2001) described intrinsic motivation to experience stimulation as when an individual engages in an activity to experience pleasant sensations (e.g. sensory and aesthetic pleasure). Deci and Ryan presented four types of extrinsic motivation: Integrated, Identified, Introjected, and External Regulation. These forms of motivation exist along a continuum wherein autonomy lessens from Integrated Regulation through to External Regulation.

Vallerand (1997) discussed the multidimensional nature of motivation and proposed the hierarchical model of intrinsic and extrinsic motivation. The model embraces several of the elements of SDT (Deci & Ryan, 1985) but provides three levels of generality. Global level motivation is similar to a personality trait and refers to a general tendency to interact with the environment in an intrinsic, extrinsic, or amotivational way. Motivation at a contextual level concerns an individual's orientation towards a specific context (e.g., exercise). Situational motivation is similar to state motivation and refers to motivation during a specific activity at a given moment in time. Vallerand also postulated that motivation leads to three consequences: affective, cognitive, and behavioural. These consequences are decreasingly positive from intrinsic motivation to amotivation.

The hierarchical model also includes interactions between the levels of generality, a postulate that has received empirical support (e.g., Blanchard et al., 2007). There are few studies that have examined how motivation at a contextual level can lead to consequences at a situational level (Amiot, Gaudrea, & Blanchard, 2004; Blanchard et al.). Amiot et al. (2004) showed that self-determined motivation at a contextual level was associated with positive cognitive consequences (perceived goal attainment) at a situational level after testing 122 athletes across a range of sports including badminton and alpine skiing. Blanchard et al. found a similar relationship between contextual motivation of basketball players and sustained interest (a behavioural outcome) at a situational level. Vallerand (2007) suggested that further research is needed to establish the associations between contextual level motivation and situational level consequences. There have been no studies to date that have explored the association between contextual motivation for exercise and situational level consequences following an exercise to music session.

There is evidence to suggest that motivational orientation is a significant personal factor in many health contexts (e.g., smoking abstinence [Niemiec, Ryan, Deci, & Williams, 2009]; alcohol consumption [Pavey & Sparks, 2010]; adherence to HIV medication [Kennedy, Goggin, & Nollen, 2004]), and exercise/physical activity contexts (e.g., Chatzisarantis, Hagger, Biddle, & Karageorghis, 2002; Edmunds, Ntoumanis, & Duda, 2007; Moreno, González-Cutre, Sicilia, & Spray, 2010). Vlachopoulos et al. (2000) examined the link between motivation (self-determined or non-self-determined) and several outcome measures (e.g., affect, attitudes, and intentions) among sports participants. They found that participants with self-determined motivation reported pleasant affective responses. Wilson, Rodgers, Fraser, and Murray (2004) identified that autonomous forms of motivation (identified and intrinsic regulation) were strongly correlated with affective and behavioural consequences in an exercise context. Wilson et al. measured motivation using the Behavioural Regulation in Exercise Questionnaire (BREQ-2; Mullan, Markland & Ingledew, 1997), however, this only includes a one-dimensional approach to intrinsic motivation. An alternative measure that embraces the multidimensional conceptualisation of intrinsic motivation is the Exercise Motivation Scale (EMS; Li, 1999). The multidimensional approach is in line with Vallerand's (1997) hierarchical model and offers a more encompassing approach to the measurement of motivational orientation.

4.1.3 Purpose of the Present Study

The purpose of the present study is to explore two psychological characteristics that might influence a person's response to music during exercise. With reference to the conceptual frameworks of music and exercise (e.g., Karageorghis et al., 1999; Terry & Karageorghis, 2006), it is expected that the present study will further our understanding of the personal factors that may influence how individuals respond to music. Moreover, greater understanding of the influence that personal factors (i.e., dominant attentional style and motivational orientation) can have on the benefits associated with music use during exercise might lead to more accurate recommendations regarding how to maximise such benefits. A recent review by Karageorghis and Priest (2012b) highlighted the need to further understand personal variables in musical reactivity within the exercise context.

Further to the recommendations of Karageorghis and Priest (2012b), the instability of the exercise heart rate-music tempo preference relationship found in Study 1 hints at the significant role that personal factors might play in determining the most appropriate music to accompany exercise. Study 1 employed rigorous control measures in an attempt to isolate music tempo as the predominant difference between experimental tracks. However, the unexpected results of Study 1 raised questions into the veracity of the music selection process and also regarding the limited knowledge of the influence that personal factors can have in music and exercise related research. Study 1 attempted to control for personal factors that are known to influence music preference (i.e., age and socio-cultural background) but no other personal factors were accounted for owing to the lack of understanding of how these might influence the effects of music during exercise. By exploring the effects of a greater range of personal factors (i.e., dominant attentional style and motivational orientation), researchers can attempt to account for such factors to a greater degree.

The present study examines the links between contextual level motivation and attentional style, and situational-level consequences. It was expected that high levels of self-determined motivation in an exercise context would be associated with positive situational consequences immediately following an exercise-to-music session. Further, Dissociators will exhibit the most positive psychological outcomes. The study does not seek to directly test the tenets of Self-determination Theory or the hierarchical model (Vallerand, 1997), but rather to use them as guiding frameworks by which to examine the associations between motivational orientation and the consequences of attending an exercise-to-music session with the potential moderating effect of attentional style. By examining the associations between motivation towards exercise (from amotivation through to three types of intrinsic motivation) and the three consequences following an exercise-to-music session, researchers can further understand the personal factors, or characteristics, that are relevant in a music-and-exercise context. Moreover, if motivation and attentional style (Association or Dissociation) are found to be associated with the outcomes following an exercise-to-music session, researchers will have a better understanding of how an individual with certain motivational and attentional styles can benefit most from music use during exercise.

The present study employs an in vivo design and follows similar work investigating the effects of music during an exercise class (e.g., North & Hargreaves, 1997; Vlachopoulos et al., 2000). The study seeks to explore how an individual's dominant attentional style and motivational orientation influence the affective, cognitive, and behavioural consequences associated with an exercise-to-music session. In line with an in vivo study design, there is no control comparator in this instance. The study seeks to explore theoretical relationships between antecedents and consequences of an exercise-to-music session and is not designed in the form of an experimental study. It is not practicable to administer a comparable exercise session given that it is highly unlikely that participants would attend a similar session performed without music. A central aim is to assess two psychological characteristics of individuals who attend exercise-to-music classes and how these influence a range of psychological consequences.

4.1.4 Hypotheses

The exploratory nature of the study is reflected in the research hypotheses. It was hypothesised that individuals with a dominant attentional style of dissociation (Dissociators) would experience the most positive outcomes (H_1). There was an exploratory examination of attentional style across behavioural regulations, but there were not expected to be significant differences between the Associators and Dissociators (H_2).

It was hypothesised that Dissociators who are highly self-determined will experience the most positive consequences (H_3). The relationships between behavioural regulations and the four outcome measures were explored and it was expected that correlations would be increasingly strong and positive as self-determination increased (H_4). The relationships between behavioural regulations and outcome measures were explored by attentional style group with the expectation that Dissociators would have the strongest and most positive correlations with the four outcome measures (H_5). The predictive strength of the relationships across behavioural regulations and the four outcome measures was explored using a multiple group structural equation model (Associators and Dissociators). It was hypothesised that the relationships between behavioural regulations and the four outcomes would differ by dominant attentional style (H_6).

4.2 Methodology

The study received approval from the Brunel University Research Ethics Committee (see Appendix E) and participants provided written informed consent. Health facilities in the southeast of England were contacted via email, and telephone. In addition, site visits were made in order to establish a list of facilities that would be willing to grant access to their members and classes. Facilities with a large membership and a large number of exercise-to-music classes were prioritised. Six health facilities were selected for the study following consideration of membership numbers, number of classes, and geographical location. The class instructors at the facilities were briefed as to the general nature of the study and asked to conduct their classes as normal. A total of 22 instructors led the classes over the six facilities and experience of leading exercise-to-music classes ranged from 3 to 15 years ($M = 8.6$ years, $SD = 3.5$ years). The classes at which the questionnaires were distributed are designed to produce significant cardiorespiratory demands and were focused on movements that engaged large muscle groups (e.g., Body Pump, Step aerobics, Spinning, and Zumba). Classes without a significant aerobic demand (e.g., yoga and

Pilates) were not included in order to maintain some homogeneity in terms of the cardio-respiratory nature of the sessions and with the music used. Typically, the music employed in yoga and Pilates sessions are more sedative in nature.

4.2.1 Participants

Participants were drawn from the general population and recruited from six leisure facilities in the southeast of England. Participants were required to complete a questionnaire before and after their exercise to music session. A total of 1,075 questionnaires were completed however, 73 of these were unable to be paired (53 pre- and 20 post-exercise questionnaires). There were a total of 501 participants who completed both pre- and post-exercise questionnaires (M_{age} = 38.2 years, *SD* = 14.3; 89.6% British nationality; 92% spoke English as first language; 83% defined their ethnicity as White; 88.2% attended secondary school in Britain). Of the 501 participants, 67 were male (M_{age} = 44.8 years, *SD* = 15.6; 89.6% British nationality; 94% spoke English as first language; 88.1% defined their ethnicity as White; 92.5% attended secondary school in Britain) and 434 were female (M_{age} = 37.2 years, *SD* = 13.8; 89.6% British nationality; 91% spoke English as first language; 82.3% defined themselves as White; 87.6% attended secondary school in Britain).

4.2.2 Measures

4.2.2.1 Attentional Focus Questionnaire. Participants' dominant attentional style was assessed using the Attentional Focus Questionnaire (AFQ; Brewer, Van Raalte, & Linder, 1996). The original AFQ asked participants to respond as if they were completing a maximal effort run. However, participants in the present study were asked to respond to the items with regard to an exercise class. The AFQ has three subscales (association, dissociation, and distress) and responses are attached to a 7-point Likert scale ranging from *Would not do at all*, to *Would do a lot*. A score for each subscale is calculated from summing all the item responses within each factor to generate three scores for each participant. There are 11 items within the association subscale (e.g., “Monitoring how hard you are working”) and scores can range from 11 to 77. There are 12 items within the dissociation subscale (e.g., “Trying to solve problems in your life”) and scores can range from 12 to 84. There are only seven items for the distress subscale and thus scores can range from 7 to 49. Brewer et al. provided evidence of the internal consistency derived from the AFQ and found alpha reliability coefficients were as follows: association (0.79), dissociation (0.77), and distress (0.85).

4.2.2.2 Exercise Motivation Scale. Participants’ contextual level motivation was assessed using the Exercise Motivation Scale (EMS; Li, 1999). The EMS is designed to categorise responses into one of eight types of motivation (Intrinsic Motivation to Know, Intrinsic Motivation to Accomplish, Intrinsic Motivation to Experience Stimulation, Integrated Regulation, Identified Regulation, Introjected Regulation, External Regulation, and Amotivation). The EMS is predicated on Vallerand’s (1997) multidimensional conceptualisation of intrinsic motivation and facilitates exploration of the associations between the three different types of intrinsic motivation and psychological consequences. With the exception of Amotivation which has three items, each of the eight subscales has four items. Participants respond to each item (e.g., “to satisfy people who want me to exercise”) on a 6-point Likert scale (anchored by *Strongly agree* and *Strongly disagree*) in accordance with how much they agree with the item in response to the question “Why are you participating in this activity?”. Alpha reliability coefficients for each subscale averaged 0.77 ranging from of 0.71 (intrinsic motivation to accomplish) to 0.85 (intrinsic motivation to learn); Li stated that these coefficients met established standards described by Nunnaly (1978). Wininger (2007) conducted further examination of the psychometric properties and found the EMS to be a valid and reliable measure.

4.2.2.3 Outcome measures. As suggested by Vallerand (1997), motivation is associated with three main consequences: affective, cognitive, and behavioural. Accordingly, in the present study, established measures were used to assess the affective (Circumplex Model of Affect; Russell, 1980), cognitive (*concentration on the task at hand* subscale of the Flow State Scale-2; Jackson & Eklund, 2002), and behavioural (behavioural intent items; Vlachopoulos et al., 2000) outcomes from participation in the exercise-to-music classes.

4.2.2.3.1 Affect Grid. The Affect Grid (Russell et al., 1989), which was derived from Russell's (1980) Circumplex Model of Affect, was used to enable participants to rate their pleasure-displeasure (affective valence) and perceived activation (arousal) immediately after an exercise-to-music class. The format is a 9 x 9 grid with participants placing an "X" in one of the 81 boxes to represent their affective valence (horizontally from unpleasantness to pleasantness) and arousal (vertically from sleepiness to high arousal). The Affect Grid has shown evidence of acceptable validity and reliability (Russell et al.) and has been used in a number of studies to differentiate between affective states in sporting contexts (e.g., Bishop et al., 2009; Edmonds, Mann, Tenenbaum, & Janelle, 2006).

4.2.2.3.2 Flow State Scale-2. The *concentration on the task at hand* subscale of the 36-item Flow State Scale-2 (FSS-2; Jackson & Eklund, 2002) was used to assess participants' cognitive responses to an exercise-to-music class. Participants responded to the four items of the scale (e.g., "I was completely focused on the task at hand") on a 5-point Likert scale anchored by 1 (*Strongly Disagree*) to 5 (*Strongly*

Agree). Scores from the subscale have demonstrated acceptable goodness-of-fit indices using confirmatory factor analysis (Jackson et al., 2008) and an internal consistency of .82 (Martin et al., 2006).

4.2.2.3.3 Behavioural intent. Participants were required to respond to three statements designed to represent their future intentions towards attending exercise-to-music classes. The three items (e.g., "I am determined to continue participating in exercise classes during this year") were initially used by Vlachopoulos et al. (2000) in a study examining the relationship between motivation profiles and a series of outcomes in a sport context. Participants responded on a 7-point Likert scale anchored by 1 (*Extremely Unlikely*) to 7 (*Extremely Likely*). Similar scales (e.g., Wilson & Rodgers, 2004) were available but it was felt that the time scale used in the items designed by Vlachopoulos et al. were more appropriate for assessment of long-term behavioural intent (one year).

4.2.3 Procedure

Individuals were approached before the start of an exercise-to-music class and asked to participate in the study. The researcher was situated immediately outside the exercise studio and engaged the participants while they were waiting for the class to begin. As an aid to recruitment, participants were offered a 500 ml can of energy drink that was given after all questionnaires had been completed (i.e., after the exercise-to-music session). The participant initially completed four forms including a written consent form, demographic information, the AFQ, and the EMS. Participants were instructed to complete the questionnaire individually and to return the forms upon completion; this process was designed to take no longer than 5 min. Participants then attended the exercise-to-music class as they would normally do.

Participants completed a second pack of questionnaires immediately after the exercise-to-music class. The pack contained basic demographic information (surname, first initial, and age) in order to enable pre and post exercise class responses to be matched correctly and a further three sections (Affect Grid, behavioural intent items, and concentration items). The post-exercise questionnaire was designed to be completed in under 2 min and therefore participants expended no longer than 7-min in total completing the pre and post exercise questionnaires.

4.2.4 Data Analysis

Using PASW Statistics 18, data were screened for univariate and multivariate outliers by firstly calculating *z* scores for each variable and then by using Mahalanobis distances. Following checks to ensure that the data were suitable for parametric analysis, a series of MANOVAs and ANOVAs was applied. A oneway independent samples MANOVA (attentional style groups) for two outcome measures (affective valence and arousal, measured using the Affect Grid) was applied. Oneway independent samples ANOVAs (attentional style groups) on cognitive (as measured by the FSS-2 subscale) and behavioural outcomes (as measured by the behavioural intent items) were applied. A oneway independent samples MANOVA (attentional style groups) for behavioural regulations (as measured by the EMS) was applied.

A combination of multivariate and univariate analyses were used to examine differences between *participant profiles* (a combination of motivational orientation, as classified by Self-determination Index [SDI], and attentional style, by Associator or Dissociator) and the outcome measures with the aim of facilitating the practical interpretation of results. The subscales of the EMS were combined into a SDI, which is calculated by assigning a weighting to each subscale. Intrinsic motivation, Integrated Regulation, and Identified Regulation are assigned +3, +2, +1 respectively as they represent self-determined forms of motivation. Conversely, Amotivation, External Regulation, and Introjected Regulation are assigned -3, -2, -1 respectively as they represented less self-determined forms of motivation. The total score calculated for each participant represents a relative level of self-determined motivation. A positive score indicates a relatively self-determined motivational profile, whereas a negative score reflects a relatively non-self-determined motivational profile (Vallerand, 1997). MANOVA was applied to participant profiles and affective outcomes. ANOVA was applied to the participant profiles and the cognitive outcome; similarly, ANOVA was applied to the participant profiles and the behavioural outcome.

A correlational analysis was conducted to explore the relationships between behavioural regulations and the four outcome measures. A further correlational analysis was conducted by attentional style groups (Associators or Dissociators) examining the correlations across behavioural regulations and the four outcome measures. A multiple group (Associator or Dissociator) structural equation model was applied using EQS 6.1 to examine the strength of relationships between behavioural regulations and the four outcome measures (see Figure 4.1). This analysis allowed for examination of differences in the strength of relationship between behavioural regulations and the outcome measures across the two attentional style groups. Initially, a baseline model of both groups was applied to examine goodness of fit. Subsequently, separate models for Associators and Dissociators were computed.

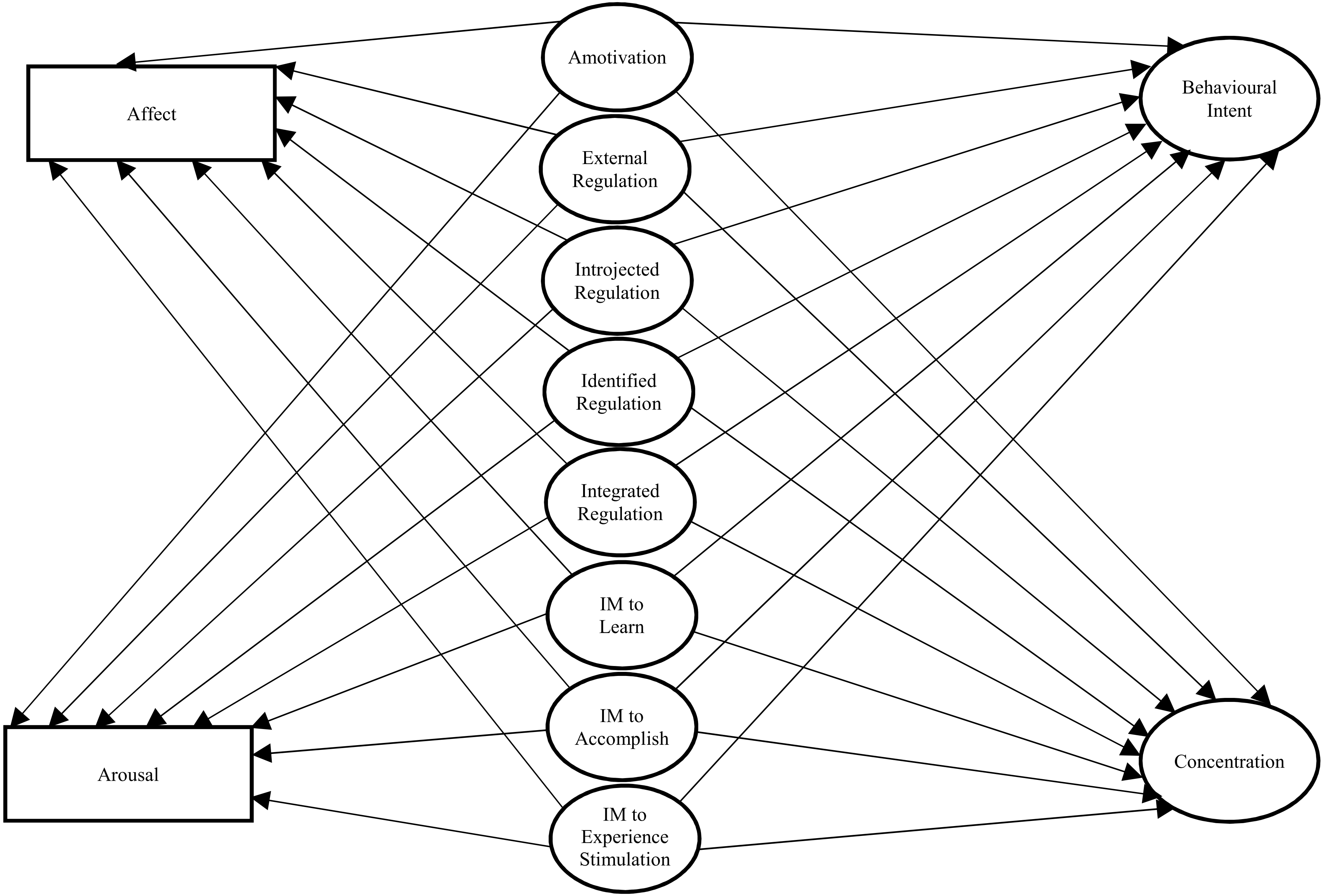

Figure 4.1. Structural model showing the hypothesised associations between motivational orientation at a contextual level and behavioural, affective, and cognitive outcome measures.

4.3 Results

The sample of males (n = 67) was insufficient to enable meaningful statistical analyses, therefore only data from females (n = 434) were used in the analyses described herein. One female participant was removed from the dataset owing to a self-reported hearing deficiency. Prior to subjecting the dataset to analysis, checks were conducted for univariate outliers ($z \geq \pm 3.29$) and multivariate outliers (at $p < .001$). This iterative process was undertaken with a view to removing outliers from the dataset prior to analysis (Tabachnick & Fidell, 2007, p. 77). The raw data were converted to standardised scores (z scores) and checks revealed 133 univariate outliers. This represents 0.4% of the total number of data points (k = 30,380) analysed for univariate outliers ($z \geq \pm 3.29$). Six cases exhibited multiple univariate outliers (three or more) and these were removed from the dataset. The remaining univariate outliers (k = 101) were assigned a raw score that was within one unit of the next most extreme score in the distribution (Tabachnick & Fidell, p. 77).

Following modification, the data were screened a second time and 106 univariate outliers were identified. Two further cases were removed from the dataset as their responses included multiple univariate outliers. The remaining outliers (k = 98) were assigned a raw score that was within one unit of the next most extreme score in the distribution (Tabachnick & Fidell). A third check revealed 24 univariate outliers. These were assigned a raw score that was within one unit of the next most extreme score in the distribution and no further cases were removed from the dataset (Tabachnick & Fidell). Checks for univariate outliers were conducted on the composite variables of behavioural intent, concentration, and Cognitive Index (CI). One outlier was identified through checks of the Concentration variable and the associated case was subsequently removed.

Checks for multivariate outliers were conducted on affective variables (scores of affective valence and perceived activation) and behavioural regulations (EMS factor scores) given that these were to be subjected to multivariate analyses. No multivariate outliers were identified for affective variables but seven multivariate outliers ($p < .001$) were identified among the behavioural regulation variables. The corresponding cases were removed from the dataset. Accordingly, a total of 17 female participants were removed as a result of a hearing deficiency, univariate and multivariate outliers. The sample size was 417 ($M_{\text{age}} = 37.5$ years, $SD = 13.7$ years) following the removal of male participants, those with a hearing deficiency, and outliers. The demographic information of the 417 participants was as follows: 89.9% were of British nationality, 90.1% spoke English as a first language, and 86.8% attended secondary education in Britain.

A Cognitive Index (CI; Masters & Ogles, 1998) was determined for each participant ($n = 417$) to enable analysis by attentional style. The CI was calculated by subtracting the association score from the dissociation score and adding 100. Masters and Ogles suggested that this provided a method by which to evaluate preference (not absolute levels) for an attentional strategy. A score over 100 indicates a preference for dissociation whereas a score equal to or below 100 indicates a preference for association. Following the calculation, there were 335 participants with a preference for association (Associators) and 82 with a preference for dissociation (Dissociators) with scores ranging from 55 to 130 ($M = 87.52$, $SD = 13.41$). Tests of the distributional properties of the data in each cell of the analysis revealed violations of normality in 19 of the 48 cells (all at $p < .01$; see Table 4.1). Tabachnick and Fidell (2007, p. 78) indicate that the F test is sufficiently robust to violations of normality provided that there are no outliers.

Table 4.1

Skewness and Kurtosis Data for Behavioural Regulations and Outcome Measures by Associators and Dissociators

Variables	Associators (n = 335)		Dissociators (n = 82)	
	Std. Skewness	Std. Kurtosis	Std. Skewness	Std. Kurtosis
Amotivation	14.42*	13.19*	3.85*	-0.13
External Regulation	8.80*	2.81*	3.33*	-0.37
Introjected Regulation	1.22	-2.09	0.88	-0.63
Identified Regulation	-5.95*	1.27	-0.45	-1.66
Integrated Regulation	-4.55*	0.40	-2.40	-0.43
IM to Learn	-2.68*	-1.57	-1.73	-0.99
IM to Accomplish	-4.19*	-0.51	-1.13	-1.15
IM to Experience Stimulation	-7.16*	2.49	-1.10	-0.67
Cognitive outcome	-5.83*	1.34	-1.71	-0.42
Behavioural outcome	-15.05*	10.74*	-4.31*	0.09
Affect	-8.05*	3.30*	-1.64	-1.40
Arousal	-5.80*	1.04	-2.70*	-0.07

* $p < .05$.

Descriptive statistics for behavioural regulation (EMS subscale scores) and outcome measures (cognitive, behavioural, and affective) are presented in Table 4.2. The Identified Regulation subscale had the highest mean score among the EMS subscales (M = 20.68), and Amotivation had the lowest (M = 4.02). Within the subscales relating to the multidimensional conceptualisation of Intrinsic Motivation, Intrinsic Motivation to Experience Stimulation had the highest mean score (M = 19.52).

Table 4.2

Means and Standard Deviations for Behavioural Regulations and Outcome Measures (n = 417)

Variables	*M* (*SD*)
Amotivation	4.02 (1.64)
External Regulation	7.05 (3.27)
Introjected Regulation	13.25 (4.33)
Identified Regulation	20.68 (2.68)
Integrated Regulation	18.09 (3.91)
IM to Learn	15.38 (4.62)
IM to Accomplish	17.89 (3.79)
IM to Experience Stimulation	19.52 (3.53)
Cognitive outcome	4.02 (0.79)
Behavioural outcome	6.68 (0.59)
Affect	7.69 (1.28)
Arousal	6.26 (2.04)

4.3.1 Analysis of Variance

A oneway independent samples (attentional style groups) MANOVA of affective valence and perceived activation is presented in Table 4.3. Box's *M* test indicated homogeneity of covariance (Box's $M = 3.602$; $p = .312$); therefore the Hotelling's Trace omnibus statistic was used. There was a significant difference between Associators and Dissociators (Hotelling's $T = .02$, $F(2, 414) = 4.24$, $p = .015$, $\eta_p^2 = .02$). Associators reported significantly ($p = .005$) higher levels of affect when compared to Dissociators. There were no significant differences between Associators and Dissociators for arousal.

Oneway independent sample ANOVAs (attentional style group) on cognitive (as measured by the *concentration on the task at hand* subscale of the FSS-2; Jackson & Eklund, 2002) and behavioural (as measured by behavioural intent items) outcomes are also presented in Table 4.3. ANOVA for the cognitive outcome was significant, $F(13, 403) = 2.58$, $p < .01$, $\eta_p^2 = .07$. ANOVA for attentional style and behavioural outcome was significant, $F(6, 410) = 2.39$, $p < .05$, $\eta_p^2 = .03$. Associators reported significantly higher levels of concentration ($p < .01$) and behavioural intent ($p < .05$) when compared to Dissociators. Figure 4.2 shows the mean affective scores for Associators and Dissociators plotted within the Circumplex Model of Affect (Russell, 1980). Figure 4.3 displays the mean scores for the cognitive and behavioural outcome measures.

Table 4.3

Descriptive and Inferential Statistics for Outcome Measures by Attentional Style

	M	*SE*	*F*	*p*	η_p^2
Arousal					
Associators	6.29	.11	.40	.529	.00
Dissociators	6.13	.23			
Affect					
Associators	7.78	.07	7.86	.005	.02
Dissociators	7.34	.14			
Cognitive					
Associators	4.11	.04	2.58	.002	.07
Dissociators	3.65	.09			
Behavioural					
Associators	6.72	.03	2.39	.028	.03
Dissociators	6.52	.07			

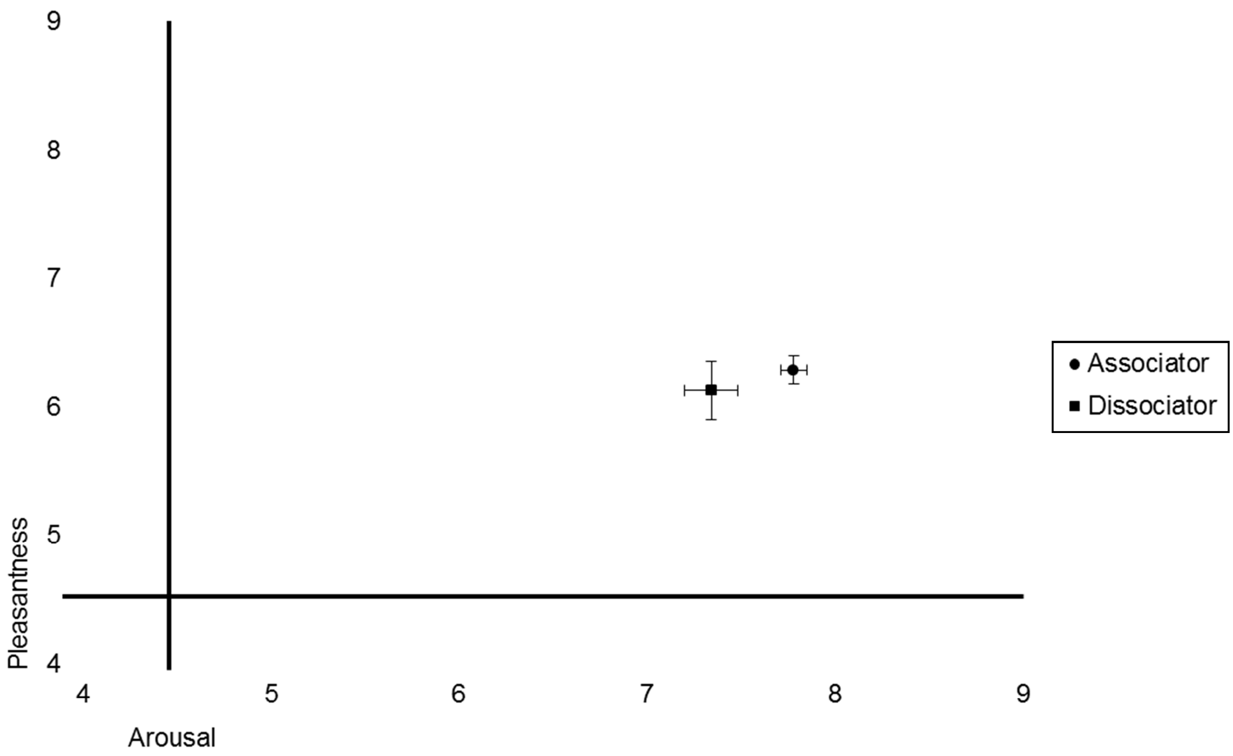

Figure 4.2. Mean affective scores for Associators and Dissociators (T-bars represent standard errors). The *x* and *y* axes have been reduced in length to place emphasis on the top-right quadrant (pleasant high activation).

Figure 4.2 shows the mean responses recorded on the Affect Grid and plotted for Associators and Dissociators using the Circumplex Model of Affect (Russell, 1980). The scores have been plotted in the Circumplex Model of Affect to illustrate the differences between the two attentional styles. Associators reported higher affective valence scores than the Dissociators following the exercise-to-music class (p = .005). There was no statistical difference in levels of arousal between the attentional styles.

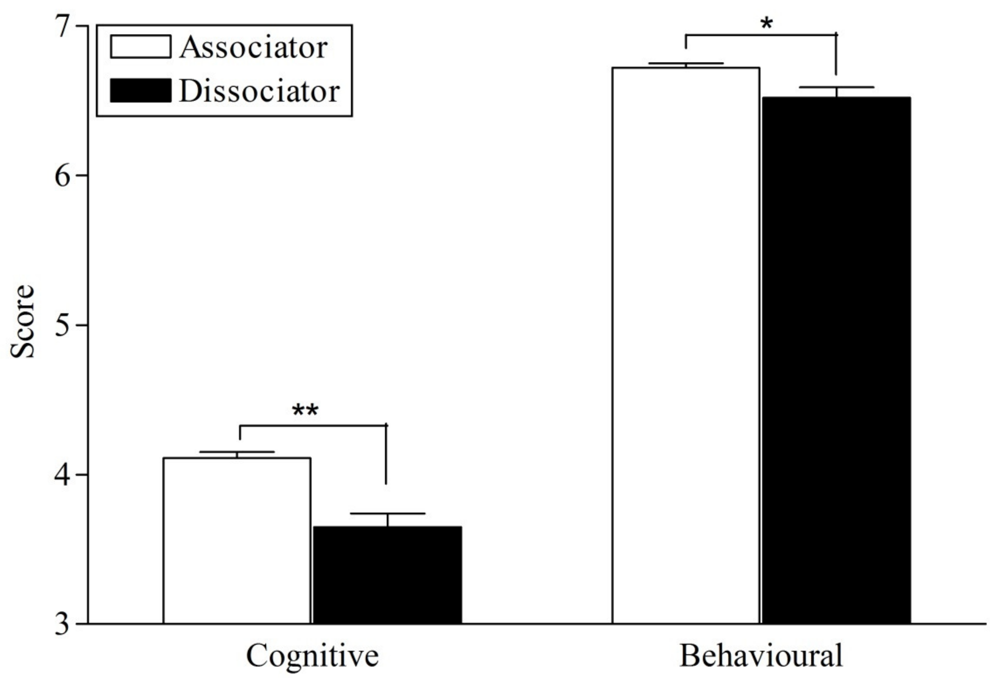

Figure 4.3. Mean scores for cognitive and behavioural outcomes for Associators and Dissociators (T-bars represent standard error).
* $p < .05$. ** $p < .01$.

Figure 4.3 illustrates the significant differences in mean scores between attentional style groups for the cognitive and behavioural outcomes. The cognitive outcome, as measured by the *concentration on the task at hand* subscale of the FSS-2, shows that Associators exhibited significantly ($p < .01$) higher levels of concentration during the exercise-to-music class. Similarly for the behavioural outcome that was assessed using three behavioural intent items, Associators achieved a significantly higher overall score than Dissociators, with Associators indicating they were more likely to continue attending the class in future.

A oneway independent samples (attentional style groups) MANOVA of behavioural regulations is presented in Table 4.4. Box's *M* test indicated violations for homogeneity of covariance (Box's $M = 79.06$; $p < .001$), therefore the Pillai's Trace omnibus statistic was used (Tabachnick & Fidell, 2007, p. 252). There was a significant difference between Associators and Dissociators (Pillai's Trace = .11, $F(8, 408) = 6.04$, $p < .001$, $\eta_p^2 = .11$). Follow-up pairwise comparisons indicated that the Associators reported significantly higher EMS scores for Identified Regulation ($p < .001$), Integrated Regulation ($p < .001$), Intrinsic Motivation to Learn ($p < .001$), Intrinsic Motivation to Accomplish ($p < .001$), and Intrinsic Motivation to Experience Stimulation ($p < .001$) when compared to Dissociators. Conversely, Dissociators reported significantly higher EMS scores for Amotivation ($p < .001$), and External Regulation ($p < .001$) compared to Associators. There were no significant differences between Associators and Dissociators for Introjected Regulation. Figure 4.4 shows the mean scores for Associators and Dissociators across each of the subscales of the EMS.

Table 4.4

Descriptive and Inferential Statistics for Behavioural Regulations by Attentional Style

	M	*SE*	*F*	*p*	η_p^2
Amotivation					
Associators	3.82	.09	27.50	.000	.06
Dissociators	4.84	.18			
External Regulation					
Associators	6.78	.18	11.77	.001	.03
Dissociators	8.15	.36			
Introjected Regulation					
Associators	13.18	.24	.52	.472	.00
Dissociators	13.56	.48			
Identified Regulation					
Associators	20.97	.14	22.01	.000	.05
Dissociators	19.46	.29			
Integrated Regulation					
Associators	18.51	.21	21.13	.000	.05
Dissociators	16.35	.42			
IM to Learn					
Associators	15.74	.25	11.00	.001	.03
Dissociators	13.88	.50			
IM to Accomplish					
Associators	18.33	.20	24.13	.000	.06
Dissociators	16.10	.41			
IM to Experience Stimulation					
Associators	19.92	.19	22.79	.000	.05
Dissociators	17.89	.38			

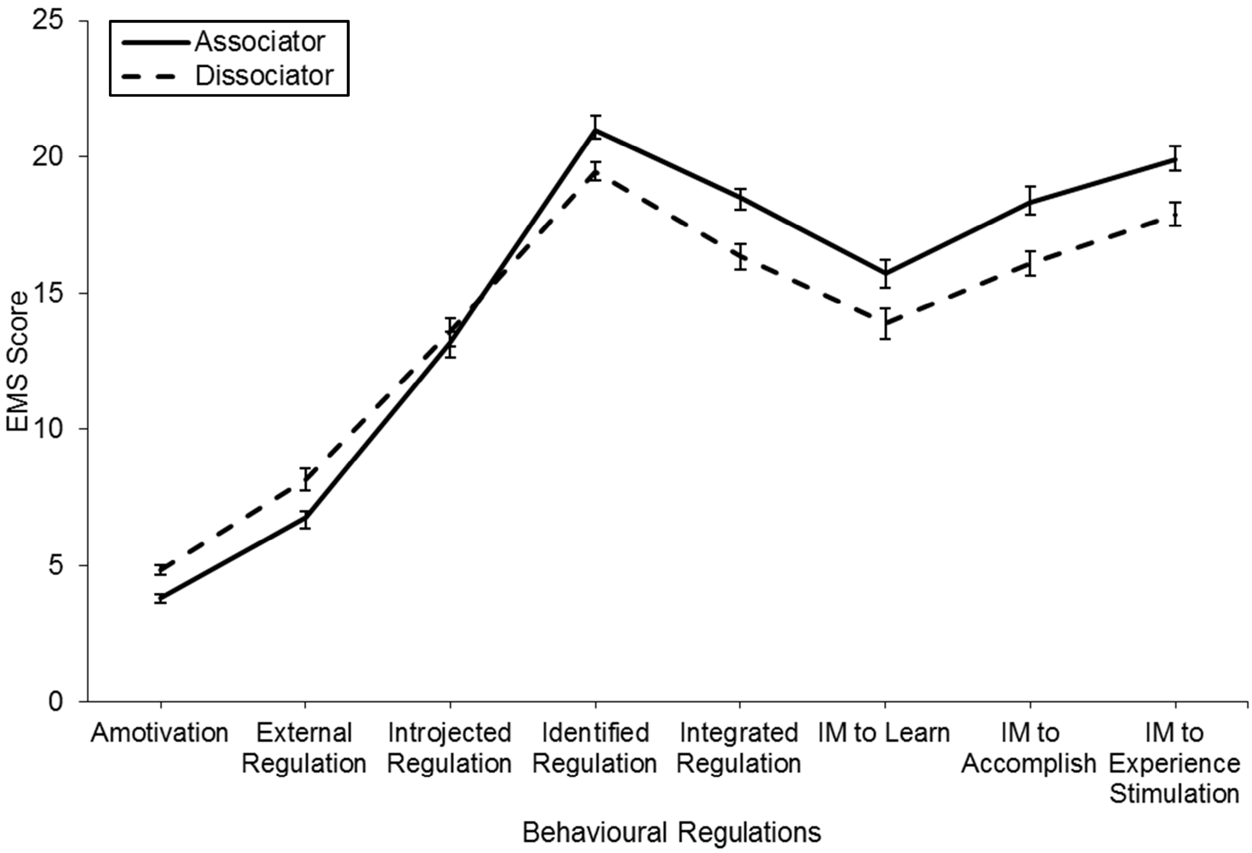

Figure 4.4. Mean EMS subscale scores for Associators and Dissociators (T-bars represent standard error).

Figure 4.4 shows that significantly higher scores were achieved by Dissociators in the Amotivation ($p < .001$) and External Motivation subscales ($p < .01$). The scores of Associators and Dissociators follow a similar pattern for the Identified Regulation, Integrated Regulation, IM to Learn, IM to Accomplish, and IM to Experience Stimulation subscales, with Associators scoring significantly ($p < .01$) higher in each subscale. There was no difference between the scores of Associators and Dissociators in the Introjected Regulation subscale.

4.3.2 Participant Profiles

The subscales of the EMS were calculated into a Self-determination Index (SDI). Individuals with a high positive score on the SDI are characterised as having self-determined motivation in a given context, while those with a negative score are also characterised as having non-self-determined motivation. Following the calculation of participants' SDI, the vast majority (99.3%) could be described as having a self-determined motivational profile as only three exhibited negative scores; it was therefore decided to use a median split on the SDI scores. The split resulted in 213 participants with an SDI of ≤ 73, and 204 participants with a score > 73. These two sub-samples were then divided by Associators and Dissociators in order to establish a series of *participant profiles* that represented the motivational and attentional characteristics of the participants. The four groups were as follows: Highly self-determined associators (HSDIA; *n* =184), highly self-determined dissociators (HSDID; *n* = 20), moderately self-determined associators (MSDIA; *n* = 151), moderately self-determined dissociators (MSDID; *n* = 62). Table 4.5 contains the descriptive statistics for EMS subscales by each of the aforementioned participant profiles.

Table 4.5

Means for the Participant Profile Group by EMS Subscale (Standard Deviations in Parentheses)

EMS Subscales	MSDIA (n = 151)	MSDID (n = 62)	HSDIA (n = 184)	HSDID (n = 20)
Amotivation	4.48 (1.72)	5.34 (2.22)	3.27 (0.78)	3.30 (0.47)
External Regulation	8.06 (3.31)	9.11 (4.05)	5.73 (2.28)	5.15 (1.42)
Introjected Regulation	13.54 (4.34)	13.68 (4.43)	12.88 (4.26)	13.20 (4.66)
Identified Regulation	19.50 (2.58)	18.95 (2.75)	22.18 (1.80)	21.05 (2.54)
Integrated Regulation	15.98 (3.38)	15.19 (3.92)	20.59 (2.57)	19.95 (1.90)
IM to Learn	13.12 (4.24)	13.06 (4.19)	17.90 (3.75)	16.40 (3.52)
IM to Accomplish	15.67 (3.10)	15.06 (3.68)	20.52 (2.38)	19.30 (2.60)
IM to Experience Stimulation	17.60 (3.40)	16.76 (3.26)	21.82 (1.86)	21.40 (2.35)

Note. MSDIA = Moderately self-determined associators, MSDID = Moderately self-determined dissociators, HSDIA = Highly self-determined associators, HSDID = Highly self-determined dissociators.

A oneway independent samples MANOVA was used to assess differences between the four participant profiles on the affective outcomes (see Table 4.6). Box's M test indicated violations for homogeneity of covariance (Box's $M = 8.078$; $p < .001$) and therefore the Pillai's Trace omnibus statistic is reported (Tabachnick & Fidell, 2007, p. 252). There was an overall multivariate effect for participant profile, Pillai's Trace = .08, $F(6, 826) = 5.52$, $p < .001$, $\eta_p^2 = .04$, associated with a small effect size. Post hoc analysis using Tukey's test indicated the following significant differences: between MSDIA and HSDID for Arousal with HSDID reporting higher scores ($p = .020$); between MSDID and HSDID for Arousal with HSDID reporting higher scores ($p = .002$); between MSDID and HSDIA for affect with HSDIA reporting higher scores (p = .001). Figure 4.5 shows the mean scores for MSDIA, MSDID, HSDIA, and HSDID plotted on the Circumplex Model of Affect.

A oneway independent samples ANOVA was used to check whether cognitive scores differed between participant profiles (see Table 4.6). There was a significant effect, $F(3, 413) = 16.66$, $p < .001$, $\eta_p^2 = .11$, associated with a moderate-to-large effect size, and post hoc analysis using Tukey's test indicated the following significant differences: between MSDIA and HSDIA with HSDIA reporting higher scores ($p < .001$); between MSDID and HSDIA with HSDIA reporting higher scores ($p < .001$); between HSDIA and HSDID with HSDIA reporting higher scores (p = .035).

A oneway, independent samples ANOVA was used to check whether behavioural intent scores differed across the four participant profiles (see Table 4.6). There was a significant effect, $F(3, 413) = 17.41$, $p < .001$, $\eta_p^2 = .11$, associated with a moderate-to-large effect size, and post hoc analysis using Tukey's test indicated the following significant differences: between MSDIA and HSDIA with HSDIA reporting higher scores ($p < .001$); between MSDID and HSDIA with HSDIA reporting higher scores ($p < .001$). Figure 4.6 shows the mean scores for the cognitive and behavioural outcome measures across participant profiles.

Table 4.6

Means and Inferential Statistics of Outcomes Measures by Participant Profiles (Standard Deviations in Parentheses)

	MSDIA	MSDID	HSDIA	HSDID	*F*	df	*p*	η_p^2
Cognitive	3.88 (0.76)	3.60 (0.87)	4.29 (0.72)	3.81 (0.64)	16.663	3, 413	.000	.11
Behavioural	6.51 (0.72)	6.45 (0.71)	6.89 (0.32)	6.77 (0.42)	17.407	3, 413	.000	.11
Affect	7.59 (1.30)	7.21 (1.38)	7.93 (1.17)	7.75 (1.25)	5.687	3, 413	.001	.04
Arousal	6.16 (1.88)	5.68 (2.15)	6.40 (2.06)	7.55 (1.96)	4.921	3, 413	.002	.04

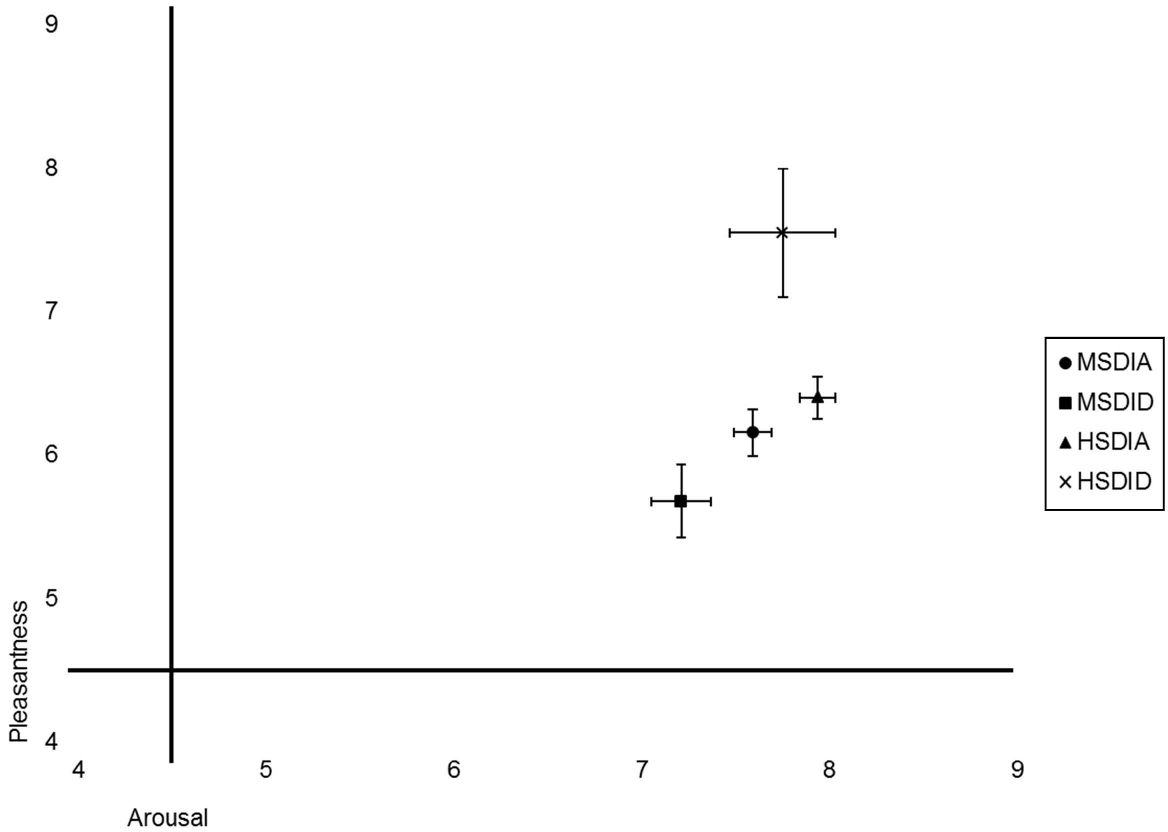

Figure 4.5. Mean affective scores for participant profiles (T-bars represent standard error). MSDIA = Moderately self-determined associators, MSDID = Moderately self-determined dissociators, HSDIA = Highly self-determined associators, HSDID = Highly self-determined dissociators. The *x* and *y* axes have been reduced in length to place emphasis on the top-right quadrant (pleasant high activation).

Figure 4.5 shows the mean scores of the Affect Grid and plotted for each participant profile. The scores have been plotted on the Circumplex Model of Affect (Russell, 1980) to illustrate the differences between the four profiles. HSDID scored significantly higher arousal than both moderately self-determined profiles, but not significantly higher than HSDIA ($p < .05$). HSDIA achieved significantly higher affective valence scores than MSDID indicating HSDIA derived greater pleasure from the exercise-to-music class than MSDID ($p = .001$). Although non-significant ($p = .061$), HSDIA also derived greater pleasure than MSDIA.

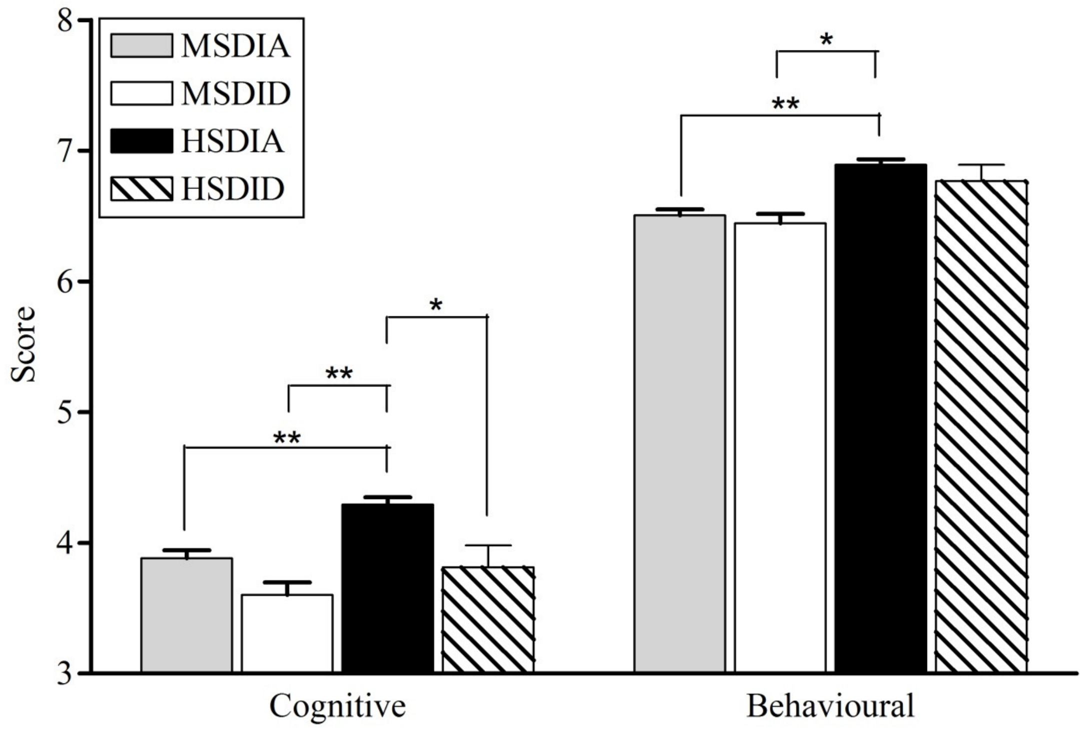

Figure 4.6. Mean scores for cognitive and behavioural outcomes for each participant profile (T-bars represent standard errors). * $p < .05$. ** $p <.001$.

Figure 4.6 shows mean scores for the cognitive and behavioural outcome measures for each of the four participant profiles. The HSDIA group scored significantly higher on the cognitive outcome measure compared to the other three profiles. There were no differences in the cognitive outcome across MSDIA, MSDID, and HSDID profiles. The HSDIA group scored significantly higher on the behavioural intent items than both profiles related to the moderately self-determined group. There was no difference in behavioural intent scores between highly self-determined groups.

4.3.3 Correlations

The relationship between motivational orientation (as measured by the EMS) and cognitive (as measured by the *concentration on the task at hand* subscale of the FSS-2), behavioural (as measured by behavioural intent items), and affective outcomes (as measured by the circumplex model of affect) was investigated using

Pearson product moment correlations. Analysis revealed 27 significant correlations between motivational orientation and outcome measures (see Table 4.7). All the relationships between Integrated Regulation, IM to Learn, IM to Accomplish, and IM to Experience Stimulation and the outcome measures were positive in nature, with Pearson's *r*'s ranging .13–.37. The relationships between Identified Regulation and the cognitive, behavioural, and arousal scores were positive with Pearson's *r*'s ranging .15–.26. The relationships between Amotivation and External motivation and the outcome measures were negative with Pearson's *r*'s ranging -.10– -.32.

Pearson's product moment correlations were computed to investigate the relationship between motivational orientation and outcome measures by attentional styles. Analysis revealed 36 significant correlations between motivational orientation and the outcome measures in both Associators and Dissociators (See Table 4.8). There were 22 significant correlations between behavioural regulations and the outcome measures of Associators. All the relationships between IM to Learn, IM to Accomplish, and IM to Experience Stimulation and the outcome measures were positive with Pearson's *r*'s ranging .15–.39. There were positive correlations between Identified Regulation and Integrated Regulation and the cognitive and behavioural outcomes (Pearson's *r*'s ranging .14– .34). There was also a significant correlation between Integrated Regulation and Arousal ($r = .13$). There were significant negative correlations between Amotivation and External Regulation and the cognitive and behavioural outcome measures with Pearson's *r*'s ranging -.21– -.34. There was an inverse relationship between External Regulation and Affect ($r = -.19$).

Results indicated 14 significant correlations between behavioural regulations and the outcomes measures of Dissociators. The correlations between IM to

Accomplish and IM to Experience Stimulation and the behavioural outcome and levels of arousal were positive with Pearson's *r*'s ranging .25–.35. There was a significant positive correlation between IM to Learn and the cognitive outcome (r = .32). The Identified Regulation and Integrated Regulation subscales were positively correlated with the cognitive and behavioural outcomes and level of arousal with Pearson's *r*'s ranging .26–.38. External Regulation was negatively correlated with level of Arousal (r = -.29) and Amotivation was negatively correlated with the behavioural outcome measure (r = -.22) and level of arousal (r = -.44).

Table 4.7

Pearson's Product Moment Correlation Results for Behavioural Regulations and Cognitive, Behavioural, and Affective Outcomes

EMS Subscales	Cognitive Outcome	Behavioural Outcome	Affect	Arousal
Amotivation	-0.22***	-0.32***	-0.14**	-0.16**
External Regulation	-0.19***	-0.23***	-0.18**	-0.10*
Introjected Regulation	-0.03	0.03	-0.05	-0.05
Identified Regulation	0.21***	0.26***	0.09	0.15**
Integrated Regulation	0.27***	0.37***	0.13**	0.16**
IM to Learn	0.30***	0.26***	0.16**	0.15**
IM to Accomplish	0.26***	0.35***	0.16**	0.19***
IM to Experience Stimulation	0.30***	0.37***	0.19***	0.20***

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4.8

Pearson's Product Moment Correlation Results for Behavioural Regulations and Cognitive, Behavioural, and Affective Outcomes by Attentional Style

	Cognitive Outcome	Behavioural Outcome	Affect	Arousal
Associators (*n* = 335)				
Amotivation	-0.21***	-0.34***	-0.10	-0.05
External Regulation	-0.23***	-0.27***	-0.19***	-0.03
Introjected Regulation	-0.07	-0.01	-0.04	-0.07
Identified Regulation	0.14**	0.22***	0.07	0.11
Integrated Regulation	0.22***	0.34***	0.10	0.13*
IM to Learn	0.26***	0.26***	0.15**	0.15**
IM to Accomplish	0.23***	0.33***	0.16***	0.15**
IM to Experience Stimulation	0.28***	0.39***	0.17***	0.16***
Dissociators (*n* = 82)				
Amotivation	-0.08	-0.22*	-0.15	-0.44***
External Regulation	0.06	-0.07	-0.09	-0.29**
Introjected Regulation	0.14	0.20	-0.09	0.01
Identified Regulation	0.28*	0.27*	0.07	0.27*
Integrated Regulation	0.26*	0.38***	0.12	0.28*
IM to Learn	0.32**	0.18	0.12	0.12
IM to Accomplish	0.17	0.33**	0.07	0.35**
IM to Experience Stimulation	0.19	0.25*	0.14	0.32**

* $p < .05$. ** $p < .01$. *** $p < .001$.

4.3.4 Multiple Groups Structural Equation Model

Using a multiple groups structural equation model (SEM), the strength of relationship between the outcome variables (affective, cognitive, and behavioural) and behavioural regulations was equal in Associators and Dissociators. Structural equation modelling tests the extent to which data can be explained using a model specified by the researcher (see Tabachnick & Fidell, 2007, pp. 676–678). There is no single test to determine the model fit therefore the most appropriate strategy is to examine multiple tests (Bentler, 1990). A good fitting model will include a non-significant chi-square, incremental fit indices of .95 (IFI; see Hu & Bentler, 1999), and a Root Mean Squared Error of Approximation (RMSEA) of lower than .08 (Browne & Cudeck, 1993), Comparative Fit Index (CFI) of greater than .95, and Bentler-Bonett Normed Fit Index (NFI) of greater than .94 (Bentler). The chi-square statistic was significant in each model ($p < .001$). Although a nonsignificant chi square is desirable, the figure is inflated by large samples and non-normally distributed data therefore becomes significant; chi square may not be clearly interpretable and therefore a range of indexes are assessed (Bentler).

SEM results for Associators (IFI = .98; RMSEA = .12; CFI = .98; NFI = .97) and Dissociators (IFI = .96; RMSEA = .17; CFI = .96; NFI = .95) indicated good fit for IFI (> .95), marginal fit for RMSEA (< .08), acceptable fit for the CFI (> .95) and good fit for NFI (> .94). Multiple groups SEM indicated support for the notion that the strength of relationship did not differ between the groups (IFI = .97; RMSEA = .08; CFI = .97; NFI = .95). The two structural equation models including the two attentional styles (association and dissociation) are presented in Figures 4.7 and 4.8 respectively.

Figure 4.7 contains a structural model for Associators. Data show that 25% of behavioural intent variance was accounted for by motivational orientation, compared to 18% for Dissociators. Path coefficients showed that high scores for IM to experience stimulation and Integrated Regulation were associated with stronger behavioural intent. High scores for Amotivation and External Regulation were associated with weakest behavioural intent. Data show that 14% of concentration variance was accounted for by motivational orientation. Path coefficients showed that high scores for IM to Learn were associated with the highest levels of concentration during the exercise-to-music class. Further, high scores for External Regulation were associated with the lowest levels of concentration during the class.

Figure 4.8 contains a structural model for Dissociators. The results of the analysis indicate that 29% of variance in affective valence was accounted for by motivational orientation. Path coefficients showed that high scores for IM to Accomplish were associated with the most positive affective valence scores; conversely, high Amotivation scores were associated with the lowest affective valence scores. Data show that 19% of concentration variance was accounted for by motivational orientation. Path coefficients indicated that high scores for IM to Learn and Identified Regulation were associated with high levels of concentration, whereas high scores for IM to Accomplish were associated with low levels of concentration. The analysis indicates that 18% of behavioural intent variance was accounted for by motivational orientation. Path coefficients showed that high scores for Integrated Regulation and IM to Accomplish were associated with stronger behavioural intent.

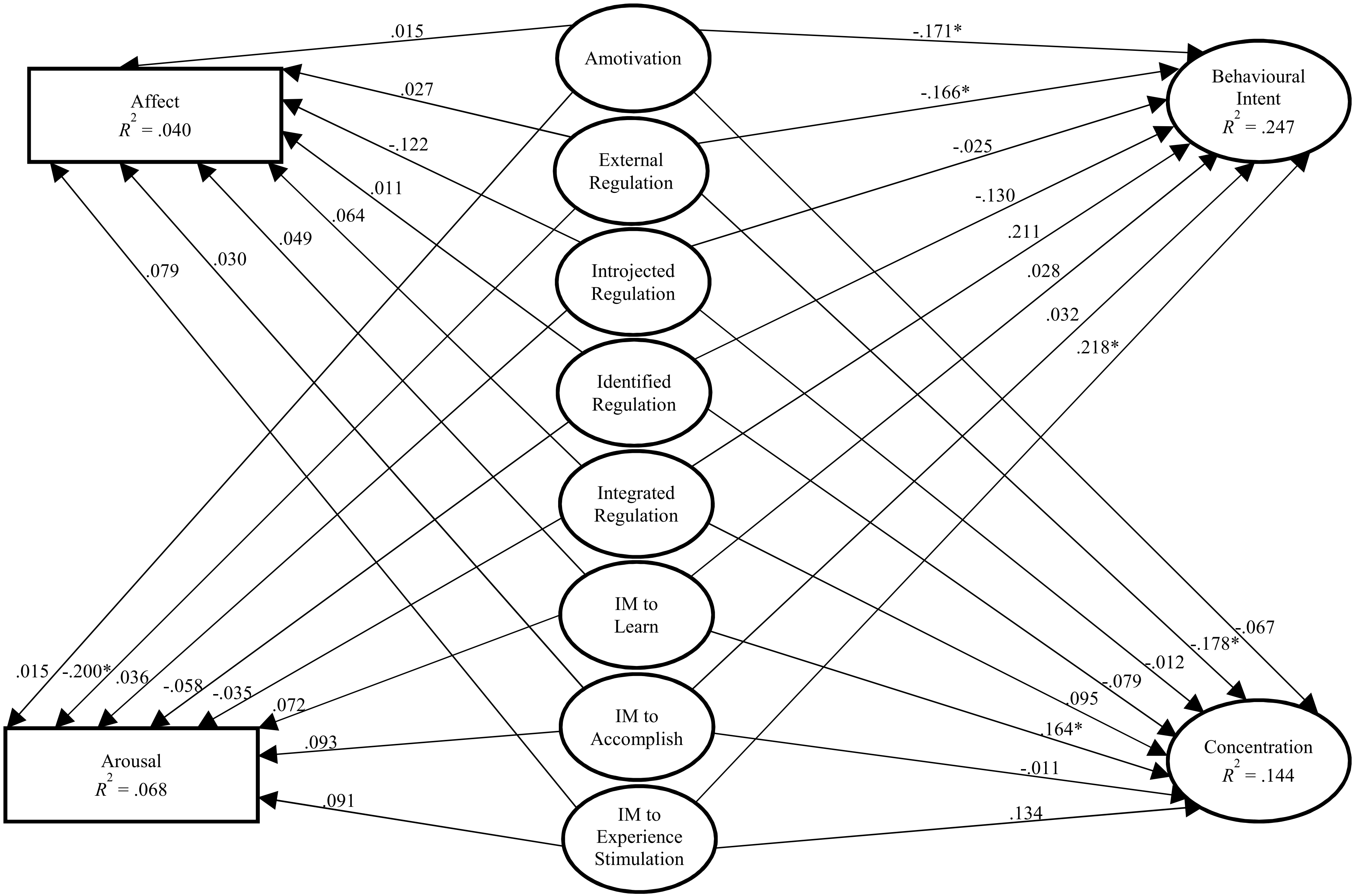

Figure 4.7. Structural model showing the associations between motivational orientation at a contextual level and behavioural, affective, and cognitive outcome measures for Associators.

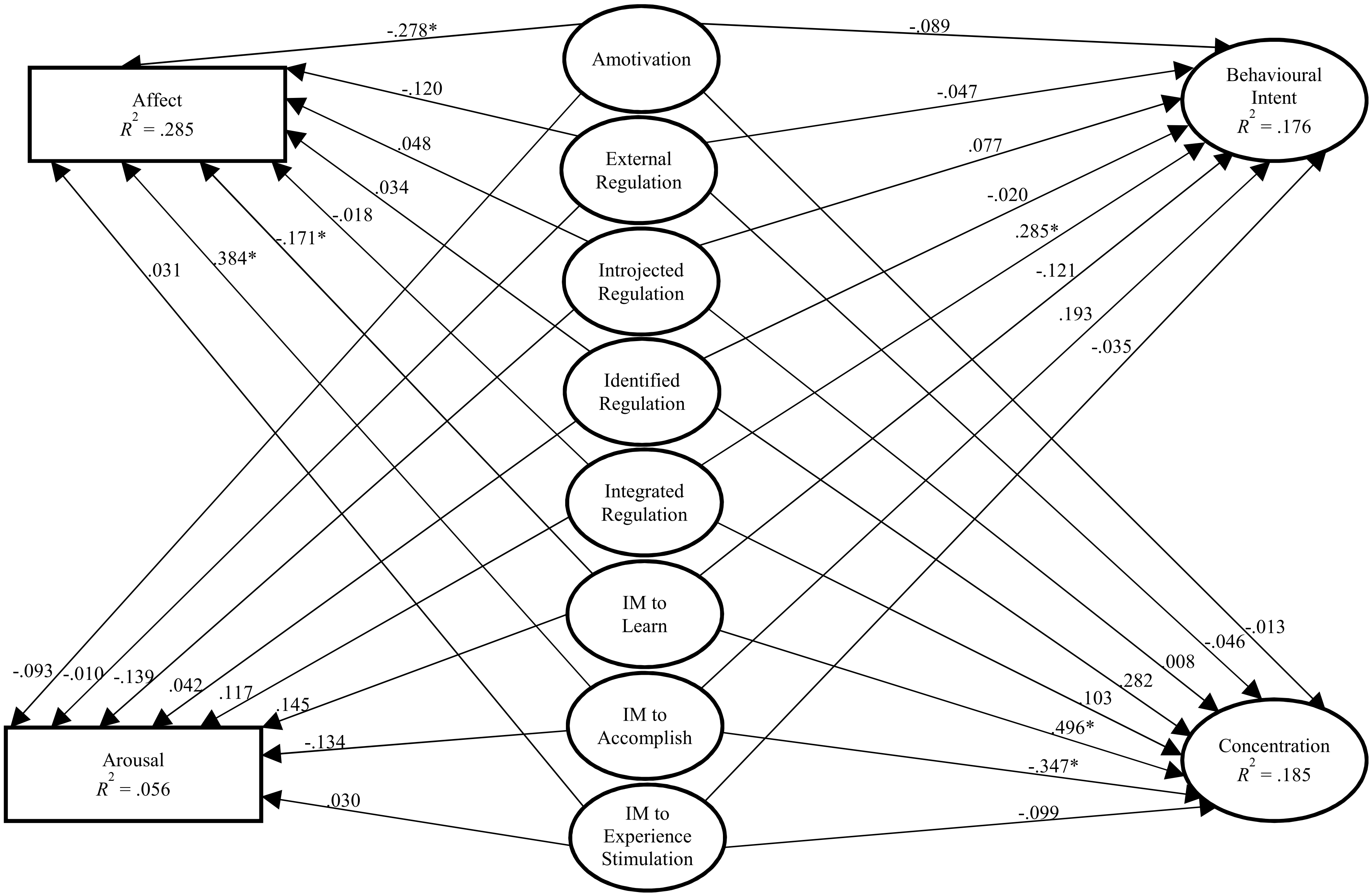

Figure 4.8. Structural model showing the associations between motivational orientation at a contextual level and behavioural, affective, and cognitive outcome measures for Dissociators.

4.4 Discussion

The purpose of the present study was to explore the influence that motivational orientation and dominant attentional style has on responses to an exercise-to-music session. The exploratory nature of this study was reflected in the research hypotheses. Exploratory analysis of behavioural regulations and attentional styles revealed an unexpected pattern. It was hypothesised that there would be no difference between attentional styles (Associators or Dissociators) across behavioural regulations (H_2), but the results do not support this hypothesis. Dissociators' recorded significantly higher scores for the EMS subscales of Amotivation and External Regulation when compared to Associators (see Figure 4.4). This unexpected finding indicates that Dissociators have, on the whole, less self-determination to exercise than those with an associative focus. This preliminary finding tentatively suggests Dissociators would stand to benefit most from interventions that enhance autonomy, competence, and relatedness in an exercise context. These three components are the building blocks of self-determination according to self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000).

The 2006 model by Terry and Karageorghis included dissociation as a potential benefit to the application of music during exercise. The notion that music serves to divert the listener's attention externally and away from internal physiological cues during an exercise has received empirical supported (e.g., Study 1). The present results may offer further insight into how individuals are using music as a dissociative tool. Contrary to the hypothesis, it was Associators who reported the most positive outcomes. This may suggest that music is not acting as a distractor wherein it focuses people's attention on irrelevant thoughts (e.g., their social activities at the weekend), but rather it focuses people's attention away from internal pain related physiological cues (e.g., painful muscles) to non-pain related internal sensations (e.g., feelings of affect). Studies exploring association and dissociation in physical activities rely heavily on physiological cues as a determinant of association or internal focus (e.g., Tammen, 1996), however an internal focus does not have to be exclusively physiological.

Music is broadly accepted as a means by which to positively influence emotions during exercise (see Karageorghis & Priest, 2012a, 2012b) and it may be that it is feelings of affect or emotions that Associators are focusing on during a music-to-exercise class. A possible explanation for the present findings may be that music is not a distractor that elicits extraneous thoughts, rather it helps people to focus on affect and emotions, instead of physiological pain sensations, and Associators are more likely to focus on these enhanced emotions than Dissociators. The Attention Focus Questionnaire (AFQ) used to determine dominant attentional style in the present study included questions to be scored within the *Associations* category that went beyond physiological cues (e.g., "paying attention to the rhythm of your movement"; "encouraging yourself to work harder"); this offers support for the notion that internal focus in an exercise context does not have to be related to physiological cues and that a definition of association that only includes such cues may be limited and not allowing for the full picture to emerge. The passive nature of music as an attentional manipulation leads to the suggestion that people are not actively focusing their attention on the music itself; rather it enhances their feelings of affect which gives the listener a positive response to focus on.

The mind and body are not distinct entities and yet the term *association* in the sport and exercise literature is referred to in predominantly physiological terms (e.g., focusing on heart rate, breathing; Tammen, 1996). Association is defined in terms of physical sensations and pain, and dissociation in terms of objects outside of the individual (e.g., counting objects in the environment; Masters & Ogles, 1998). One can still focus inwardly and not exclusively on indices described as physiological; focus can be on how one feels, but the current association/dissociation literature in sport and exercise does not account for this. Masters and Ogles asserted that the dichotomy of association versus dissociation may represent an oversimplification of the cognitions occurring during exercise. They explain that this is evidenced by the wide range of strategies that could be considered external (e.g., daydreaming, talking, and counting). In their 1998 paper they continued with the term dissociation owing to its precedence but suggested that further research will facilitate decision making about appropriate terms. To date, the terms association and dissociation continue to be used in the manner described by Masters and Ogles.

Stevinson and Biddle (1998) responded to the Masters and Ogles review of the association/dissociation literature by reiterating their two-dimensional classification system of association/dissociation that included task-relevant and task-irrelevant thoughts. Nonetheless, this system by Stevinson and Biddle does not account for internal sensations that are non-physiological, and all *relevant internal* sensations (e.g., breathing, perspiration) were physiological in nature, and *irrelevant internal* sensations (e.g., daydreams, maths puzzles) did not include affective or emotional responses. Core affect is a constant and is described by Russell and Feldman-Barrett (1999) as "the most elementary consciously accessible feeling" (p. 806). The current measures of association/dissociation do not adequately account for a focus on affective sensations and it may be these that are of particular relevance in a music and exercise context. Individuals with an associative focus may be focusing internally on the enhanced affect brought about by the music.

The hypothesis that Dissociators would experience the most positive psychological outcomes cannot be accepted (H_1). Associators had significantly ($p < .05$) more positive responses for affective, cognitive, and behavioural outcomes (see Table 4.3, Figure 4.2, and Figure 4.3). This may suggest that individuals may be using the music in the sessions for a different purpose; one that is not solely for distraction. This finding warrants further investigation but it may be that music helps Associators to achieve a sense of flow (Csikszentmihalyi, 1990). Flow state has been described as the apotheosis of intrinsic motivation (Pates et al., 2003), and can be achieved when there is an optimal balance between the level of challenge and skill. Individuals with an associative attentional style in the present study had the highest levels of intrinsic motivation at a contextual level. Vallerand's (1997) Hierarchical Model of Intrinsic and Extrinsic Motivation and subsequent empirical studies show that motivation at a contextual level is associated with motivation at the proximal level of generality (i.e., from contextual to situational level motivation). The strong associations between contextual level to situational level motivation offer support for the notion that those individuals with an associative attentional style (and high self-determination) may be using music as a way to experience flow state (a form of intrinsic motivation).

Flow was listed as a potential benefit in Terry and Karageorghis's (2006) conceptual model, but given the lack of explicit description of personal factors as antecedents to this benefit, it may be that Associators are more likely to experience flow state in music and exercise contexts. Further, Csikszentmihalyi (1990) proposed that individuals who perform activities for intrinsic reasons are more likely to experience flow. The present findings show that Associators had significantly higher scores for intrinsic motivation. The notion that Associators are using music as a means to achieve flow state offers support to the findings of Priest and Karageorghis (2008) wherein several participants interviewed on their experiences of music in an exercise context described their experiences in terms consistent with that of flow state (Csikszentmihalyi), but the predominant response by participants in their study was that music served as a distraction.

Results show that Associators reported more a positive cognitive outcome than Dissociators with significantly higher levels of *concentration on the task at hand* (see Table 4.3 and Figure 4.3). The primary task was the exercise routines and the present results show that Associators concentrated on the exercise to a greater extent than Dissociators. This offers further support for the notion that individuals use music during exercise for reasons beyond distraction and Associators may use music as a means to help them to concentrate on the exercise task. Further, individuals who were within the participant profile HSDIA (Highly self-determined Associators) reported the most positive cognitive outcomes (see Table 4.6 & Figure 4.6), which does not support H_3. Those individuals classified as HSDIA reported the highest levels of *concentration on the task at hand* and it is interesting to note that individuals within this profile had the highest level of IM to Learn compared to the other profiles. This motivation to learn in an exercise context coupled with the associative attentional style may explain the significantly higher concentration scores.

Associators reported higher scores on the behavioural intent outcome suggesting that they are more likely to continue attending exercise classes in the future. This difference was associated with a small effect size ($\eta_p^2 = .03$) and the meaningfulness of this result is questionable. However, results of the participant profiles suggest a more meaningful difference with a moderate effect size ($\eta_p^2 = .11$).

Specifically, HSDIA reported the most positive behavioural intent with significant differences between the moderately self-determined profiles but not with HSDID. This may suggest that motivational orientation is of more importance to future behaviour than an individual's dominant attentional style. There is extensive evidence to support the link between self-determined motivation and behavioural intent (see Ng et al., 2012).

As the personal factors of motivational orientation and attentional style have not been previously examined in a music and exercise context, it may be that the potential benefits proposed by Terry and Karageorghis (2006) are more appropriate for individuals with certain characteristics. The present results show a more self-determined approach to exercise is positively correlated with high levels of affective, cognitive, and behavioural intent measures. Conversely, low self-determination in this context is negatively related to affective, cognitive, and behavioural intent outcomes. The differences found between attentional styles in response to the outcome measures also suggest that this personal factor, along with motivational orientation, may have an influence on whether an individual will experience the benefits of music use during exercise at the same intensity as another individual. It seems that differing levels of self-determination and different attention styles will result in the benefits to a certain extent, but some people may feel the benefits more intensely than others. The results of the present study suggest that those benefits stated in the 2006 model related to affective and cognitive outcomes (i.e., improved mood and flow state) may be more pronounced in individuals who are highly self-determined and those who have an associative attentional style. This list of potential benefits included in the 2006 model is not exhaustive and music use during exercise can engender a greater number of responses than those currently listed including:

positive affective states (e.g., Hutchinson et al., 2011), and enhanced adherence (e.g., Annesi, 2001). It may be that these benefits are also influenced by motivational orientation and attentional style as the present study demonstrates that these personal factors can influence psychological outcome measures.

Perceived activation did not differ by attentional style, suggesting that there may be a ceiling effect with perceived activation that is not influenced by dominant attentional style (see Table 4.3 and Figure 4.2). Interestingly, there was a significant difference evident when participant profiles were compared (see Figure 4.5). Highly self-determined Dissociators (HSDID) experienced greater levels of arousal compared to the other participant profiles. Table 4.5 offers some description of each participant profile and individuals within the HSDID profile recorded highest scores for IM to Experience Stimulation compared to other types of motivation. Further, results of the correlational analysis revealed that high levels of IM to Experience Stimulation were most strongly correlated with high levels of arousal (see Table 4.7) and the strength of this correlation increased among Dissociators. It is likely that individuals in the HSDID group were using the exercise-to-music session as a way to experience stimulation associated with their senses (e.g., sensory and aesthetic pleasure; see Vallerand, 2007). Although the motivation to experience stimulation may have led to an increase in perceived activation during an exercise-to-music class, there was no significant increase in affect compared to the other groups (see Figure 4.5).

To help facilitate the practical interpretation of the results, a series of four participant profiles was created. The four profiles consisted of highly self-determined Associators, highly self-determined Dissociators, moderately self-determined Associators, and moderately self-determined Dissociators. There were no meaningful groups that could be created with individuals that could be described as having low self-determined motivation and this was somewhat expected given that the participants in the present study were actively attending exercise-to-music classes and were not a sedentary sample (see Teixeira, Carraca, Markland, Silva, & Ryan, 2012). Vlachopoulos et al. (2000) stated that profiles can offer a fresh perspective into motivation in sport and exercise contexts and that profiles should be simplified in a way that allows for meaningful categorisation. Their profiles were a result of cluster analysis but a similar approach in the present design led to profiles that lacked real-life relevance. It is hoped that the profiles created here can be used to help inform development of future conceptual models and the application of music during exercise.

The hypothesis pertaining to these profiles (H_3) proposed that the group consisting of highly self-determined Dissociators would experience the most positive consequences, but this hypothesis was not supported. Overall, it was the profile categorised as highly self-determined Associators that recorded the most positive responses with regards to affect, cognitive, and behavioural outcomes. The differences between the highly self-determined groups and moderately self-determined groups regarding the outcomes were expected, but the difference between the highly self-determined Associators and Dissociators with regards to the cognitive outcome was not anticipated. This finding may offer an insight into how Associators are using the music and lends support for the earlier suggestion that they are using music as an aid to enhancing flow state. This is owing to the cognitive outcome measure in the present study being a subscale of the Flow State Scale-2 (Jackson & Eklund, 2002) and concerned concentration on the task at hand. A high level of concentration is a key marker of flow state and it appears that Associators have higher levels of concentration during an exercise-to-music session.

Examination of the results pertaining to the relationships between behavioural regulations and outcome measures led to the acceptance of the H_4. It was hypothesised that correlations between behavioural regulations and outcome measures would become increasingly strong and positive as motivation became more self-determined. Table 4.7 shows a clear pattern of negative correlations between Amotivation and the outcome measures that shifts towards a positive correlation between intrinsic motivation and the outcome measures. The trend was to be expected and unsurprisingly the strongest and most positive correlations were between IM to Experience Stimulation and the outcome measures.

An unexpected finding was that behavioural regulations had stronger and more positive correlations with Associators (see Table 4.7) compared to Dissociators (H_5). Upon inspection of the strength of correlations between EMS scores and the outcome measures there were 27 significant results; subsequent inspection of the results by attentional style appears to reveal that a dissociative attentional style weakened the correlations (as there were 14 significant correlations) rather than an associative style increased the strength of the correlations (as there were 22 significant correlations; see Table 4.7and Table 4.8). The effects of attentional style on the relationships between behavioural regulations and the outcome measures was examined further using a multiple group structural equation modelling approach.

Hypotheses relating to the multiple group structural equation models (H_6) are not accepted. It was expected that Dissociators would have the most positive responses but the results indicate that both models (Associators and Dissociators) were of acceptable fit and that attentional style did not moderate the strength of relationships between behavioural regulations and the outcomes measures. An interesting finding from the multiple group structural equation models was the amount of variance relating to affect that could be explained by the behavioural regulations by attentional style. Almost 29% of the variance in affect could be explained by behavioural regulations for Dissociators compared to only 4% for Associators. This indicates that affect is a more significant part of the exercise-to-music session for Dissociators than Associators as a much greater amount of variance in affect can be explained in the Dissociator group. Another noteworthy result from the multiple group structural equation models was the difference in the amount of variance for behavioural intent that could be explained for by behavioural regulations between attentional style groups. For Associators, 25% of the variance could be explained by behavioural regulation but this figure was 18% for Dissociators. This could indicate that exercise-to-music sessions are appropriate for those with an associative attentional style with regards to maintaining exercise in the future. The higher behavioural intent score for Associators may be a result of the higher self-determination within this group compared to Dissociators.

The finding that 29% of the variance for affect was attributable to behavioural regulations of Dissociators strengthens the earlier suggestion that exercise-to-music classes could be a valuable tool with this group as a means to enhance self-determination in an exercise context. It has been shown in several studies that music can enhance affective valence during and immediately post exercise compared to exercise completed in the absence of music (e.g., Study 1; Elliott et al., 2005). Affect appears to be a significant aspect of the exercise-to-music session for Dissociators. Williams et al. (2008) provided evidence of the link between acute affective responses to bouts of exercise and adherence to exercise programmes after 6 and 12 months. The findings of the present study, in conjunction with the link between affect and exercise adherence (Williams et al.), offers some justification for the use of exercise-to-music classes as interventions with Dissociators who have low-to-moderate self-determination in an exercise context.

The higher percentage of variance for behavioural intent that could be explained by a dominant attentional style of association compared to dissociation (25% to 18%) might suggest, along with the other results presented here, that an associative focus leads to amplified responses following an exercise-to-music session. This is an interesting finding and when taken in conjunction with the affective responses, and leads to implications for the affect-adherence relationship (Williams et al., 2008). The present results offer tentative support for this link insomuch that individuals who reported greater affect also reported stronger behavioural intentions. In line with the notion that acute affective responses predict physical activity behaviour, the present results suggest that Associators may be more likely to continue attending exercise classes in the future.

The results of the exploratory analysis indicated that Associators had a more self-determined motivational orientation than Dissociators and may offer explanation as to why Associators experienced more positive consequences. A tentative suggestion is that attentional style contributes to the motivational orientation of an individual. Engelmann, Damaraju, Padmala, and Pessoa (2009) suggested that a growing body of evidence indicated that attention and motivation are “intimately tied” (p. 1). Studies have provided evidence for an attention-motivation interaction and that stimuli with motivational significance preferentially engage attention, and this included stimuli with positive emotional valence (e.g., Anderson, 2005; LaBar et al., 2001; Most, Smith, Cooter, Levy, & Zald, 2007). The present study design could not ascertain whether dominant attentional style contributes to the motivational orientation of an individual in an exercise context and further studies examining causality are warranted.

The notion that attention can be driven by motivation provides a possible explanation for the observed links between dominant attentional style and motivational orientation (see Figure 4.4). Extant literature has demonstrated that an individual's attention is drawn more strongly to stimuli that fulfil an apparent need. LaBar et al. (2001) demonstrated this phenomenon by showing images of food to hungry participants; similarly, Most et al. (2007) demonstrated this by showing images of nude females to young men. The results of the present study suggest that individuals who are externally regulated tend to favour a dissociative attentional style. External regulation is defined by external reinforcement such as gaining rewards or avoiding punishment (Hagger & Chatzisarantis, 2007).

In light of the work by LaBar et al. (2001) and Most et al. (2007), it is plausible that individuals who are externally regulated to exercise use the music during an exercise class as a means by which to avoid punishment. The punishment in this context may be the negative consequences often experienced during exercise (e.g., negative affect, increase in physical pain). Individuals who are externally regulated are not participating in exercise for the enjoyment of the activity; and the results of the present study suggest that these individuals seek distraction as a means by which to help themselves in tolerating the exercise session. They may attend exercise-to-music sessions as the music offers an obvious distraction from the exercise that they do not enjoy. The design of the present study precludes confirmation of such a suggestion and a different study design than the one employed here would be required to determine the veracity of these claims.

Specifically, a study that explores why and how individuals who are externally regulated towards exercise use music during such classes would offer considerable insight.

Examining the relationship between behavioural regulations and additional personal factors provides further possible explanations for the associations between dominant attentional style and motivational orientation found in the present study. Ingledew, Markland, and Sheppard (2004) conducted a study with a similar methodological approach to the present study as data were collected from leisure facility users and the users' motivation towards exercise was assessed. They found that external regulation was positively correlated, and intrinsic motivation was negatively correlated with neuroticism. Eysenck (1982) described neuroticism as reflecting differences in the intensity of emotional experiences and Gray (1981) suggested that neuroticism is indicative of higher sensitivity to punishment. Therefore, individuals who are highly neurotic are more likely to seek avoidance of negative emotional states. With regards to the present study, music may help to reduce the negative emotional states associated with exercise and this may offer some explanation as to why those with low self-determination (externally regulated) seek such an external stimulus; the music is used to avoid or minimise the intense negative emotional consequences (feelings of negative affect) of exercise.

The motivation measure used in the present study (EMS; Li, 1999) is an exercise-specific instrument. It has previously been established that individuals with a more self-determined orientation are more likely to adhere to exercise in the long-term (Edmunds et al., 2007), and will be the predominantly task-focused (Hagger & Chatzisarantis, 2007, p. 5). Given that the identification of Associators (as measured by the AFQ; Brewer et al. 1996) in the present study included questions pertaining to task-relevant aspects of exercise, it is plausible that a convergence among the measures accounts for the findings that self-determined individuals are more likely to have an associative attentional style.

There has been limited research to date examining the links between motivation towards exercise at a contextual level and situational level outcomes (e.g., Blanchard et al., 2007). Vallerand (2007) stated that this was an area that required further investigation and this study offers support for the significant association between contextual level motivation and situational level consequences. Specifically, high levels of self-determined motivation at a contextual level (exercise) were associated with the most positive consequences at a situational level (following an exercise-to-music class; see Table 4.7). These findings are consistent with previous research although the majority of these have been conducted outside an exercise context (e.g., education and sport).

Data were collected from both women and men attending exercise-to-music classes but there were an insufficient number of male participants to enable meaningful statistical analyses both between and within sexes. The exercise-to-music classes were characterised by a predominance of females and this was reflected in the sample (~87% female). The higher number of female attendees at exercise-to-music classes is consistent with previous studies that have been conducted in a similar environment (e.g., Priest et al., 2004; Ransdell, Vener, & Sell, 2004; Simpson et al., 2003; Vlachopoulos & Karageorghis, 2005). Previous research examining the differences between male and female responses to music in an exercise context has found sex to be a factor worthy of consideration (e.g., Crust & Clough, 2006) but the influence of sex in this context remains equivocal. Given that findings have suggested sex can have a role to play in regards to responses to music during exercise, particularly when it comes to personality factors (Crust & Clough), the relevance of a sample that included both males and females would be limited. Therefore, owing to an insufficient number of males for meaningful statistical analyses between and within sex and the limited relevance of a mixed-sex sample, the decision was taken to exclude male data from the present study. Accordingly, the results are only generalisable to women attending exercise-to-music classes.

A central aim of this study was to explore whether motivational orientation and attentional style are relevant *personal factors* in the conceptual models of motivational music in an exercise context (Karageorghis et al., 1999; Terry & Karageorghis, 2006). Contextual motivation (exercise) appears to be a significant contributor to outcome measures including affect, concentration, and behavioural intent following an exercise-to-music session. This was an anticipated finding and is consistent with the significant body of literature that demonstrates strong links between self-determined motivation (at a contextual level) and positive psychological outcomes. Researchers should be aware that an individual's level of motivation for exercise can influence the effects of music during exercise, but that individuals with moderate levels of self-determination will have positive affective, cognitive, and behavioural responses following an exercise-to-music session. Results suggest that the attentional style of an individual (Dissociator or Associator) should be a consideration for researchers examining the effects of music during exercise. Both Dissociators and Associators experience positive outcomes following an exercise-to-music session, but it is Associators that appear to experience these outcomes more intensely.

4.4.1 Practical Implications

The results support previous research suggesting that self-determination is associated with the most positive consequences. Therefore, it should be an aim for practitioners in an exercise-to-music context to enhance the self-determination of participants within their charge. With regards to addressing the three building blocks of self-determination (autonomy, competence, and relatedness), music in an exercise-to-music session can enhance autonomy by allowing the participant to select the music that is played to give them a sense of choice about their exercise experience. This poses problems in a group exercise-to-music session but could be workable if each of the attendees were to suggest a small number of tracks that the instructor could incorporate into the session. Further, participants could be given a choice of exercise routines to complete within the session which may enhance their sense of autonomy. If the participant is given a choice of routines within an exercise-to-music session, this may also help to address their sense of competence as a routine more suited to their physical abilities may provide them with an optimal challenge.

Priest and Karageorghis (2008) suggested that music used in gymnasia settings may create a sense of shared experience, and that this is particularly evident within an exercise-to-music class. This sense of shared experience is a key aspect of relatedness and offers a method by which those with low self-determination in an exercise context may seek to alter their motivation to a more self-determined style.

4.4.2 Limitations of the Present Study

A notable limitation is that baseline levels of affective, cognitive, and behavioural measures were not recorded. Although the results suggest that Associators experience the most positive psychological outcomes, it may be the case that Dissociators experience the greatest *change* in psychological outcomes between pre and post an exercise-to-music session. The practicalities of a study design of this nature would be extremely challenging as it would demand additional time from the participants prior to the session, something which proved a significant challenge even within the current participant-friendly protocol.

The role of exercise intensity in ratings of affect is significant. Dual-mode model suggests that there is a consistent increase in affective valence up to the point of ventilatory threshold (Ekkekakis, 2003). Beyond ventilatory threshold there is an inter-individual variability which can result in feelings of either pleasure or displeasure. At very high exercise intensities (above respiratory compensation point: ~90% $VO_{2\,max}$) there is a uniform affective response of displeasure. In this study, it was not possible to control or measure the exercise intensities at which individuals were working. All the exercise-to-music sessions included in the data collection had a significant aerobic demand but it is likely that some participants would have been working significantly beyond their ventilatory threshold whereas others would not have been. This limitation cannot be addressed in such a design but it is hoped the high external validity of the study adds value to the work.

The instructors of an exercise-to-music class are an extremely significant factor. It was not possible to control for the actions (verbal or non-verbal) of the instructors in the present study and this presents a further limitation. The further research in this area moves towards greater ecological validity, the less control researchers have over such extraneous variables (Thomas, Nelson, & Silverman, 2011).

The measure used to assess the cognitive outcome from the exercise-to-music class was the subscale *concentration on the task at hand* from the FSS-2 (Jackson & Eklund, 2002). Items within this subscale may have favoured individuals with a predominantly associative attentional style. Associators were identified using the AFQ (Brewer et al., 1996), which includes items such as “concentrating on the session” as indicators of an associative focus. Therefore, it may have been that the questions assessing *concentration on the task at hand* (e.g., “My attention was focused entirely on what I was doing”) were more suited to an associative attentional style and thus more likely to be rated highly by Associators.

The conceptual models used as a basis for the present study (Karageorghis et al., 1999; Terry & Karageorghis, 2006) are predicated on the notion of motivational music. The list of potential benefits is only relevant if the music used during exercise is considered motivational (see Karageorghis et al.). There was no measure in the present study that assessed the motivational qualities of the music used during the exercise-to-music classes, and this represents a limitation of the design. The instructors who led the classes had an average of 8.6 years’ experience and an assumption was made that they were capable of selecting music that their charges would find motivating, or at the very least not demotivating.

The present research design and analyses were unable to address the issue of causality and cannot isolate the effects of music; therefore conclusions pertain to the consequences of a combination of music and exercise. The identification of a causal relationship between two variables presents a challenge to researchers as numerous unforeseen and uncontrollable factors can influence an effect (Harris, 2008). In an attempt to more accurately identify causality, the present design would require significant modification that includes baseline measures, control groups, and rigorous control over the environment in which the sessions were conducted (including music and instructors). Some of these issues have been addressed in this section, but a fundamental reason for this inability to infer causality is one of feasibility. The scope of such a study was beyond the means of the research programme and the implementation of controls would detract from the high ecological validity that characterised the study.

4.4.3 Future Directions

The personal factors examined herein are only two of a myriad of psychological characteristics that may influence the relationships between music factors and benefits of music use during exercise as presented by Terry and Karageorghis (2006). The examination of other relevant characteristics is encouraged to further understand the precise nature of how personal factors influence musical factors, which in turn influence benefits. The examination of Eysenck's theory of personality (introverts and extroverts) seems particularly relevant to this field of research owing to the differing levels of arousal required by these two personality types. Further, North and Hargreaves (2008) advised that musical preferences tend to reflect rather than compensate for personality traits and presented evidence that *sensation seeking* (Zuckerman, 1979) is associated with loud and fast music. Sensation seeking has not previously been addressed in a music and exercise context and also represents a personal factor that warrants further research.

The present study indicates that motivational orientation and attentional style can influence the intensity at which an individual experiences affective and cognitive outcomes. The participant profile of HSDIA had the most positive affective, cognitive, and behavioural responses whereas the MSDID group had the least positive. It may be appropriate to subject participants who fit these profiles to experimental testing under more internally valid conditions in order to test the veracity of these findings. The 2006 model suggested that dissociation, enhanced mood, and reduced ratings of perceived exertion are potential benefits of music during exercise only when considered in conjunction with personal factors. If the results of this study are to be incorporated into any such model depicting a more expansive list of personal factors that are significant to the benefits of music use during exercise, the results presented here require corroboration with the benefits listed in the 2006 model (e.g., dissociation and flow). On a similar point, individuals who were in the HSDIA group had the strongest behavioural intent, and those in the MSDID had the weakest (see Table 4.6 & Figure 4.6). In order to examine the reliability of this result, a longitudinal study examining the exercise adherence of participants with these profiles over a 12-month period would be beneficial.

In future experimental studies, researchers can seek to incorporate personal factors of dominant attentional style and motivational orientation into their designs. Owing a greater understanding of how such personal factors can influence responses, and potentially implementing controls to account for them, researchers may be able to more accurately identify the precise reasons for the possible differences in psychological or psychophysiological outcomes between experimental conditions.

Data analysis was conducted using only females attending exercise-to-music sessions for reasons previously discussed. It would be appropriate to replicate the study design with a sufficient number of males to explore whether similar trends and differences emerged. Recruitment of a sufficient number of male participants from exercise-to-music classes would present a significant challenge given the predominance of female attendees at such classes. It may be that examining males, along with females, in a more tightly controlled laboratory environment represents a more realistic option to explore whether sex moderates the relationships between motivational orientation, attentional focus, and the potential benefits of music use during exercise.

4.5 Conclusions

Overall, motivational orientation and attentional style are personal factors that should be considered by researchers examining responses to music during exercise. Individuals who are self-determined in an exercise context experienced the most positive psychological outcomes measures (affective, cognitive, and behavioural) following an exercise-to-music session. Similarly, Associators experienced the most positive psychological outcomes.

Attentional style appears to be related to the intensity of affective, cognitive, and behavioural outcomes following an exercise-to-music session. However, individuals will derive positive benefits following an exercise to music session regardless of attentional style. Associators were shown to experience the affective, cognitive, and behavioural outcomes with greater intensity when compared to Dissociators. Individuals with different attentional styles are likely to use music in contrasting ways during exercise. Those with an associative style may use the music to help focus on non-pain related internal sensations such as positive emotions that are stirred by the music. Dissociators are likely to use the music in the session in the previously accepted mode, which is to draw attention externally and away from physiological cues.

Motivational orientation and attentional style appear to be noteworthy personal factors that influence responses following exercise-to-music classes. In the conceptual models presented by Karageorghis et al. (1999) and Terry and Karageorghis (2006) personal factors are antecedents to the list of potential benefits of the application of music during exercise. Therefore, the inclusion of motivational orientation and attentional style should be considered in future conceptual models that delineate antecedents and consequences in music and exercise contexts.

Chapter 5: Psychological and Psychophysiological Effects of Music and Video during Exercise

5.1 Introduction

One of the most compelling challenges of the 21st century in health and exercise psychology has been how to arrest the decline in physical activity and the corresponding increase in sedentary behaviour that is evident across Western societies (Biddle, O'Connell, & Braithwaite, 2011). The challenges lie in encouraging individuals to engage in habitual physical activity and for that activity to be of a level at which they are likely to derive cardiorespiratory benefits. There is a clear dose-response relationship between levels of physical activity levels and a host of health-related outcomes, such as lower incidence of cardiovascular disease and reduced mortality (Garber et al., 2011). Health professionals from a wide range of disciplines have reached the consensus that engagement in regular physical activity is a central facet of a healthy lifestyle (Berlin & Colditz, 1990; Church, LaMonte, Barlow, & Blair, 2005; McAuley et al., 2009). However, there is a paucity of evidence on how the affective experiences of participants might be improved. Music and video are two obvious targets for research into this important question given their popularity among exercisers, precisely as a means of improving the overall affective experience of exercise.

Music and exercise researchers often cite *attentional dissociation* as a potential cognitive mechanism underlying the psychological, psychophysical, and ergogenic effects of music. Such researchers are referring to the capacity that music has to draw attention externally and away from internal fatigue-related cues. Evidence has shown that dissociation is linked with a more positive exercise experience (e.g., Study 1; Nethery, 2002). Based on the premise that humans have a limited attentional capacity, the dual-task paradigm offers a framework by which to examine how individuals divide this capacity across or between tasks. When the paradigm is applied to sport and exercise, the physical activity being engaged in normally becomes the primary task. The secondary task depends on the precise question that is posed, but replication of tasks experienced in the "real world" (e.g., driving and verbal tasks, soccer dribbling and auditory distraction) have the highest external validity and have been used in experimental literature (e.g., Beilock, Carr, MacMahon, & Starkes, 2002; Recarte & Nunes, 2000). One method by which to test the dual-task paradigm is to use capacity interference wherein the cumulative attentional demands of multiple tests exceed the available capacity. When applied in an exercise context, this overload of attentional capacity results in the availability of less processing for any secondary task such as processing of auditory and visual stimuli.

Tenenbaum's (2001) social-cognitive model of attention, that proposes the relationship between physical effort and attention allocation, and Rejeski's (1985) parallel processing model both posit that the intensity of exercise determines the extent to which an external stimulus such as music can inhibit the processing of other sensory cues. Moreover, Rejeski suggested that the limited capacity of the afferent nervous system is relevant in terms of the degree to which an individual is able to focus on external environmental cues (e.g., scenery, significant others, sounds, etc).

5.1.1 The Dual-Mode Model

After decades of concentrating on cognitive variables, such as self-efficacy, researchers are now also beginning to consider the possible role of affective variables in an exercise context, such as pleasure and enjoyment (e.g., Ekkekakis, Hargreaves, & Parfitt, 2013). Preliminary findings suggest that affective variables may be significant (e.g., Williams, Dunsiger, Jennings, & Marcus, 2012) or substantial (e.g., Rhodes et al., 2009) predictors of physical activity. This has been acknowledged by the American College of Sports Medicine (2013), which states in its guidelines for exercise prescription that "…feelings of fatigue and negative affect ...can act as a deterrent to continued participation" (p. 374).

Researchers have shown how the interpretation of fatigue-related symptoms is a crucial factor in determining one's enjoyment of and potential adherence to an exercise regimen. The *dual-mode model of exercise-induced affective responses* (Ekkekakis, 2003) has been particularly influential in this regard over the last decade. The model was, in part, the product of an attempt to address a sense of *dualism* that pervaded the area; the division of mind and body. Acevedo and Ekkekakis (2006) argued that proponents of the view that mind ascribes primacy over the body (e.g., Lazarus, 1984; Bandura, 1997) and vice versa (e.g., Dishman, 1994) did not adequately combine their theoretical and methodological approaches to form satisfactory integration.

The dual-mode model suggests that affective responses to physical activity are a product of two general factors that interact with one another. The first is *cognitive factors* (originating primarily in the frontal cortex), such as personal goals and self-efficacy, and the second is *interoceptive cues*, which concern muscular or respiratory sensations that reach affective centres of the brain (e.g., the amygdala, anterior cingulate cortex, and insular cortex). The salience of these factors in determining exercise-related affect shifts markedly in accordance with exercise intensity: cognitive factors are more salient at low-to-moderate exercise intensities whereas interoceptive cues are more predictive of affect as the exerciser approaches their aerobic capacity (i.e., all-out physical effort).

One of the key differences in the theoretical approach of Ekkekakis (2003) when compared to previous related models (e.g., Rejeski, 1985; Tenenbaum, 2001) is that, according to the former, fatigue-related symptoms can be interpreted as either positive or negative. More specifically there is greater scope for individual variability in interpretation at moderate-to-high exercise intensities than there is at low and very high intensities. There is fairly homogeneous interpretation during low-to-moderate intensity exercise (pleasant) and very high-intensity exercise (unpleasant) but heterogeneous interpretation during activity around ventilatory threshold, which represents moderate-to-high intensity exercise for most recreationally active individuals.

Ventilatory threshold has been shown as a critical turn-point for attentional focus and affective responses (e.g., Ando et al., 2005; Ekkekakis et al., 2008). Ekkekakis (2003) suggested that affective responses proximal to ventilatory threshold vary between individuals and that variability is driven by factors such as tolerance of somatic sensations associated with exercise. Individuals stand to gain considerable health benefits from exercise at intensities proximal to ventilatory threshold (see Fletcher et al., 1996) and interventions that enable a positive increase in affective valence at such intensities could be a powerful tool in the fight against public health issues related to physical inactivity. It has previously been shown that it is the intensity of exercise rather than frequency that is related for non-adherence (e.g., Perri et al., 2002). However, a recent review suggested that it may not be appropriate to link adherence to physical activity guideline characteristics (e.g., intensity, frequency) but rather social-cognitive, personality, and environmental factors (Rhodes, Warburton, & Murray, 2009).

5.1.2 Theory-based Empirical Research

Tenenbaum's (2001) social-cognitive model of attention has received empirical support in the literature. For example, Hutchinson and Tenenbaum (2007) examined the attentional focus of participants during a 5-min cycle ergometry task at a range of exercise intensities (50% and 70% of aerobic capacity and at aerobic capacity [$VO_{2\ max}$]) and found that attentional focus differed significantly with association increasing markedly as the intensity of exercise increased. Similarly, Connolly and Tenenbaum (2010) reported that junior rowers exhibited a shift from predominantly dissociative, to predominantly associative thoughts when tested at increasing intensities of 30%, 50%, and 75% of their maximal power output.

The dual-mode model has received empirical support over the last decade (e.g., Ekkekakis, Parfitt, & Petruzzello, 2011; Parfitt et al., 2006; Welch et al., 2007; Williams et al., 2008). Parfitt et al. showed that sedentary participants had significantly lower ratings of affect in prescribed exercise conditions above lactate threshold compared to below. Welch et al. provided broad support for the pattern of affective responses across exercise intensities but suggested that the "zones" of transition may occur earlier in inactive participants when compared against the active participants who were used to inform the original model (Ekkekakis, 2003).

Studies that have specifically tested the postulates of the dual-mode model have found that ratings of pleasure-displeasure exhibit a quadratic decline (inverted-J) when the exercise intensity exceeds the ventilatory threshold (Ekkekakis et al., 2011). This appears indicative of the rising influence of interoceptive cues. Ekkekakis (2003) reported negative correlations of increasing magnitude between ratings of pleasure-displeasure and physiological indices of intensity (e.g., oxygen uptake, respiratory exchange ratio, blood lactate). Accordingly, based on postexercise interviews, Rose and Parfitt (2010) found that above the ventilatory threshold most participants reported focusing on their physiological responses to exercise.

5.1.3 Music Interventions during Exercise

There are two distinct modes of music use during exercise: *synchronous* and *asynchronous*. Both of these applications have been shown to positively influence psychophysical and ergogenic outcomes (e.g., Hutchinson et al., 2011; Terry et al., 2012). Synchronous use of music during exercise entails a conscious attempt to move in time to the beat of the music and this approach has been shown to engender significant ergogenic effects (e.g., Karageorghis et al., 2009; Simpson & Karageorghis, 2006). The asynchronous use of music during exercise refers to when an individual makes no conscious attempt to synchronise their movements to the beat of the music and its use in exercise has been shown to confer positive psychological, psychophysical, and to a lesser extent, ergogenic effects (e.g., Elliott et al., 2004; Karageorghis et al., 2013; Szmedra & Bacharach, 1998). Evidence supporting enhanced affect and reduced sensations of exertion (e.g., Boutcher & Trenske, 1990; Hutchinson et al., 2011), alongside the ease with which it can be applied, makes the asynchronous use of music during exercise a viable intervention with a non-athlete population (i.e., general public).

Enhanced flow state has been cited as a potential benefit to the application of music during exercise (Terry and Karageorghis, 2006). Flow has been described as state wherein an experience seamlessly unfolds from moment to moment and is attained under two conditions: a sense that one is engaging in a challenge at a level that is commensurate with one's capacities; clear proximal goals and immediate feedback about progress (Nakamura & Csikszentmihalyi, 2002). Flow has been measured in the music and sport and exercise literature (e.g., Pates et al., 2003; Karageorghis et al., 2008) owing to the propensity of music to enhance the components of flow (e.g., absorption in an activity, transformation of time). Results from a 2008 study indicated that flow state was significantly higher in all music conditions compared to no-music when completing a bout of exercise lasting ~26 min (Karageorghis et al.,). In support of this, the results from Study 1 showed that exercise completed in the absence of music led to consistently lower levels of flow (Table 3.4).

Study 1 examined the effects of exercise intensity on attentional focus across conditions that included a range of music tempi (slow to very fast). It was hypothesised that the most positive psychological outcomes would be associated with the most appropriate tempo at each intensity. Overall, the results from Study 1 showed a weak association between preferred music tempo across exercise intensities and a range of psychological outcomes (e.g., affective valence). However, the findings were similar to that of Hutchinson and Tenenbaum (2007) as the attentional shift from predominantly dissociative to predominantly associative thoughts occurred at ~69% maxHRR (~65% $VO_{2\ max}$ in Hutchinson & Tenenbaum) when exercising without music; but a key finding was that the attentional shift occurred at ~78% maxHRR during the fast-tempo condition (see Figure 5.1). Although Hutchinson and Tenenbaum (2007) used work intensities based on VO_2max and Study 1 employed work intensities based on maxHRR, the American College of Sports Medicine (2006) have reported that direct comparisons between

VO_2max and % maxHRR are acceptable as they are broadly regarded as equivalent measures of work intensity.

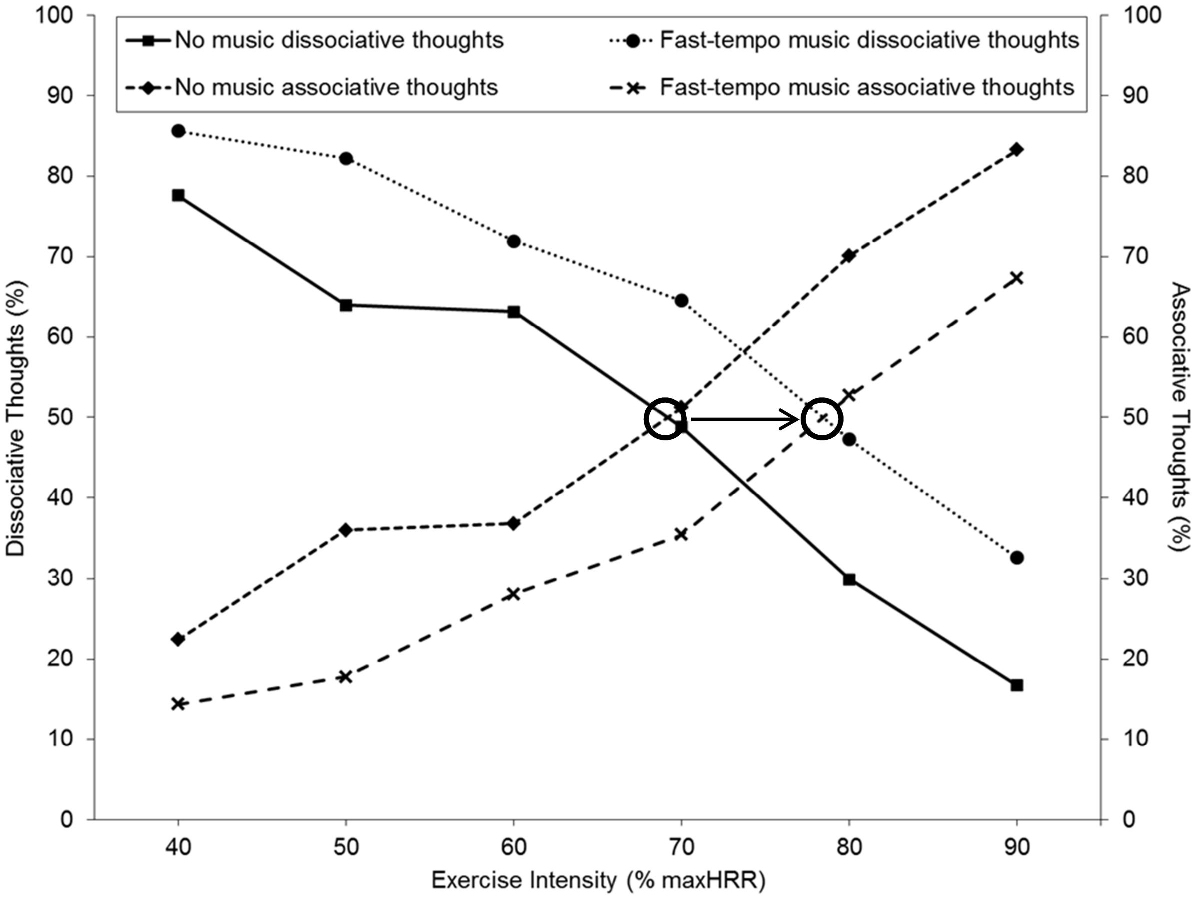

Figure 5.1. Comparison of state attention scores across exercise intensities between no-music control and fast-tempo music conditions. Adapted from Study 1.

It is pertinent to note that exercise intensities in Study 1 were determined using %HRR, not ventilatory threshold. Although ventilatory threshold was not established for participants in Study 1, Azevedo et al. (2011) found ventilatory threshold to be equivalent to 70%HRR for men under 30 years of age with high cardiorespiratory fitness. On the premise that 70%HRR is used as a proxy for ventilatory threshold, the results of Study 1 offer initial evidence that attentional focus and affective valence can be manipulated beyond ventilatory threshold.

A function of music during exercise is to regulate activation in accordance with task demands. North and Hargreaves (2008) proposed a link between the stimulative properties of music and its function in different situations; specifically, the more activation a situation required, the greater preference for stimulative music. The properties that govern whether a piece of music is stimulative are complex; North and Hargreaves suggested it was predominantly the tempo and intensity (volume) of a track that mediated its arousal potential and empirical research in an exercise context has partially supported this (e.g., Karageorghis et al., 2011). The relationship between arousal (measured using heart rate) and preference for music tempo is nonlinear and there appears to be a narrow range of tempi that are most preferred across a wide range of exercise intensities (measured using % HRR). Tempi in the range of 123–140 bpm appear to offer an appropriate level of stimulation for the arousal required across a range of exercise intensities (see Study 1). However, it may be the case that stimuli in addition to music during exercise alters the level of stimulation felt by an individual which may no longer match the activation requirements of a situation. Further, additional or alternative stimuli may provide a more appropriate level of activation as required by the task.

5.1.4 Personal Factors

Karageorghis et al. (1999) acknowledged the role of personal factors in determining the consequences of listening to music during exercise in their conceptual framework. The personal factors of age and socio-cultural background have been controlled in the design of numerous studies exploring the effects of music in exercise (e.g., Karageorghis et al., 2008; Karageorghis et al., 2011) in an attempt to limit the influence that these factors can have on responses to music. A suggestion to emanate from Study 1 of the present research programme was that a lack of control over personal factors in music and exercise research designs may have accounted for some of the unexpected findings. The influence of personal factors remains an under-explored area within music and exercise-related research (Karageorghis & Priest, 2012b), with only a limited number of related studies to date (e.g., Crust and Clough, 2006; Priest et al., 2004). Study 2 in the present research programme found evidence to suggest that dominant attentional style and motivational orientation were relevant personal factors to consider in experimental music and exercise research designs. By attempting to control for personal factors known to influence the psychological responses to music during exercise, researchers can design studies with higher internal validity.

5.1.5 The Exercise Environment

The visual and auditory environment in which people engage in exercise is cited by a burgeoning number of researchers as playing a seminal role in people's emotional responses to exercise and indicating the degree of their adherence (e.g., Annesi, 2001; Hartig & Staats, 2006; Karageorghis & Priest, 2012a, 2012b; Pretty et al., 2005; Staats & Hartig, 2004). For example, people consider exercise in a natural environment to be more attractive to them than exercise in an urban environment (e.g., Hartig & Staats; Staats & Hartig). Several studies have shown that the aesthetic quality of the surrounding environment increases in affect (e.g., Focht, 2009), mood (e.g., Barton & Pretty, 2010), and the amount of exercise done (e.g., Ball, Bauman, Leslie, & Owen, 2001; Humpel, Owen, & Leslie, 2002). Hug et al. (2009) suggested that the theory of attention restoration (see Kaplan, 1995) may offer an answer as to why aesthetically pleasing environments appear to enhance affective states and promote exercise. Hug et al. found that the restorative qualities of outdoor exercise are superior to its indoor equivalent.

Kaplan (1995) proposed a framework with the aim of integrating the psychological benefits (stress reduction and the recovery of the capacity to focus attention) identified through studies examining the benefits of nature. Restoration entails psychological distance from a person's usual routines, focus of attention, and can be seen as immersion in a physical or conceptual environment (Hartig, Kaiser, & Bowler, 2001). A central facet of restoration theory is that of directed attention and subsequent effortless attention in order to recover from a fatigued attentional state. Natural environments have been shown to promote effortless attention and therefore help restore the ability to direct attention to a task. This effortless attention is the result of many complex factors within an environment but fascination has been cited as a key factor (Kaplan). It is conceivable that a natural environment provides sufficient stimulation to capture the attention of an individual during a range of exercise intensities.

Although exercise in a natural environment has been associated with positive psychological benefits, it presents a challenge for researchers seeking to incorporate outdoor exercise into their designs. During the early stages of empirical investigations, such as the present study, high internal validity through stringent methodological controls is of paramount importance to ensure the effects of the intervention can be accurately measured. With regard to the present study and the significance of exercise intensity in the design, it would not be appropriate to conduct the study in an environment where these strict methodological controls cannot realistically be enforced; the re-creation of aesthetically pleasing outdoor environments in the laboratory is a viable option.

To date, there have been few studies that have examined the effects of video footage during exercise (e.g., Barwood et al., 2009). As such, there is no consensus as to which type of video footage might be considered motivational. Unlike music, there are no guiding conceptual frameworks with which to determine the motivational qualities of video footage. In the absence of such guidance, it is proposed that video considered to be pleasant (a positively valenced emotion) is an appropriate stimulus to use in conjunction with and comparison to music when investigating the psychological outcome during exercise. Moreover, the capacity for pleasant video to act as a distractor is of central concern to the present study as a principal aim was to ascertain the attentional focus of participants during exercise. In presenting a visual stimulus that has the capacity to engage participants (through the presentation of attractive footage; Pretty et al., 2005), video footage of a pleasant outdoor environment is deemed a suitable comparator to music in the absence of guidance. There is scant research to support the use of video during exercise, and this study represents a preliminary investigation into the use of a visual stimulus that could be used alongside or to replace music during exercise. Given the lack of understanding of what video content is considered motivational, it is acknowledged that there may be incongruence between the motivational qualities of the music and video footage employed in the present study.

5.1.6 Objective Measurement

Attention can be measured using several behavioural, cognitive, and physiological techniques but concordance between these methods is not always high. The limitations associated with each of these techniques make it rather difficult to determine which single measure would be most appropriate in an experimental protocol. The use of multiple measures to assess attentional workload appears to be a logical strategy, and it has been suggested that physiological and cognitive measures used in tandem complement the strengths and weaknesses of each technique

(Abernethy, 2001). The collection of objective measures (e.g., Heart rate variability; HRV) alongside subjective ones (e.g., affect, perceived activation, flow, and enjoyment) will likely confer a better understanding of effects that music and video stimuli can have on outcome measures during exercise.

Numerous studies have established the scientific value of the information derived from HRV measures beyond that which can be implied by heart rate (e.g., Bertsch, Hagemann, Naumann, Schachinger, & Schulz, 2012; Kleiger et al., 1987). Heart rate variability can be analysed using different approaches (e.g., time-domain and frequency domain). The frequency domain is the most commonly used approach in psychophysiological research (Berntson et al., 1997) and this method has allowed researchers to associate physiological measures with psychological responses. Appelhans and Luecken (2006) argued strongly that HRV is an accessible tool that researchers can use to increase the understanding of emotional responses to environmental stimuli. They provided a theoretical and empirical basis for the application of HRV as an index of regulated emotional responses. Within the frequency domain, high frequencies are a result of parasympathetic nervous activity and associated with positive emotions, contrastingly, low frequencies are a result of sympathetic nervous activity and related to negative emotions. There are however, concerns that HRV power spectral analysis does not accurately estimate autonomic activity during exercise (see Perini & Veicsteinas, 2003).

Perini and colleagues have sought to examine the effects of exercise on HRV from a physiological perspective in a number of studies (e.g., 2000, 2002, and 2003). In their 2003 study, Perini and Veicsteinas showed that low-frequency amplitude gradually decreased as exercise intensity increased and high-frequency amplitude increased sharply during high intensity exercise. HRV is an established measure of mental workload within certain subfields of psychology (e.g., ergonomics) but has not been widely used in the realm of exercise and physical activity. The measurement of changes in HRV frequency during exercise with music has received scant attention from researchers (i.e., Yamashita, Iwai, Akimoto, Sugawara, & Kono, 2006).

Ekkekakis and Petruzzello (1999) identified weaknesses that have blighted studies assessing affective responses: the timing of affective assessments, the assessment of affect, and the standardisation of exercise intensity. The present study was designed to ensure these pitfalls were not followed and seeks to incorporate the recommendations regarding timings, measurement, and exercise intensity.

The present study was predicated on the notion that a dissociative manipulation of attentional focus through music and video during exercise can delay the transition to the associative state and that this effect will be reflected in subjective indices of experience such as affect and enjoyment. Therefore, the purpose was to examine the effects of external stimuli (asynchronous music and video footage of parkland) on psychological variables (affective valence, perceived activation, attentional focus, and enjoyment) at intensities 10% below ventilatory threshold and 5% above during stationary cycling.

5.1.7 Hypotheses

It was expected that the music-and-video combined condition would lead to greater positive affect, increased activation, greater amounts of dissociative thoughts, higher flow state, increased enjoyment, and changes in HRV variables when compared to single stimulus (music or video) and control conditions when exercising below ventilatory threshold (H_1). Moreover, that single stimulus conditions would show differences on all outcome measures when compared to the control condition during exercising below ventilatory threshold (H_2). It was expected that the three experimental conditions (music-and-video combined and two single stimulus conditions) would show differences on all outcome measures compared to the control condition when exercising above ventilatory threshold (H_3).

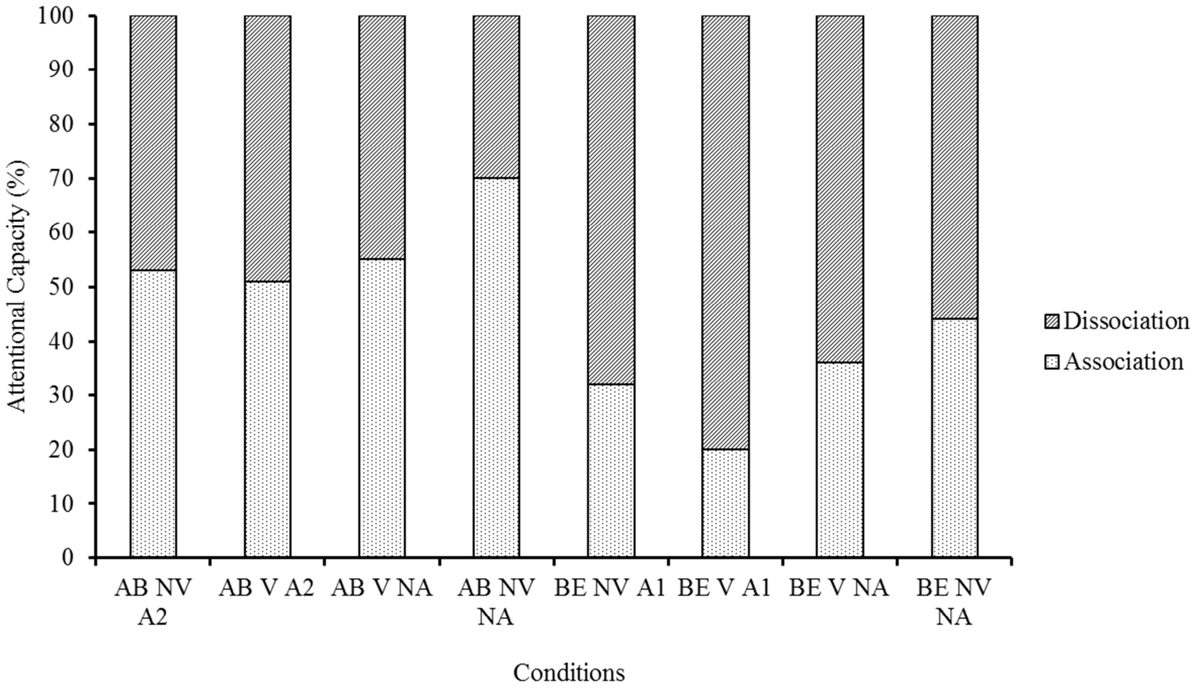

Figure 5.2. Visual depiction of attentional focus hypotheses across all conditions. AB = 5% above VT, BE = 10% below VT, NV = No video, V = Video, A2 = Music playlist 2, A1 = Music playlist 1.

5.2 Methodology

The study received approval from the Brunel University Ethics Committee (see Appendix F) and participants provided written informed consent.

5.2.1 Stage 1 – Selection of Auditory and Visual Stimuli

5.2.1.1 Music selection.

5.2.1.1.1 Participants and procedure. A sample of 153 volunteer sport sciences students (M_{age} = 19.5 years, *SD* = 1.6 years) from Brunel University were used to identify possible music selections for use in the experimental protocol of Stage 2. Given the personal factors that influence music preference, participants at each stage of the present study were similar in terms of age (18–25 years), race (Caucasian), and socio-cultural background (spent their formative years in the UK; see Karageorghis & Terry, 1997; North & Hargreaves, 2008, pp. 107–111). Participants reported no form of hearing deficiency.

Participants were asked to record their five favourite pieces of music for cycle ergometry. Subsequently, the selections were classified by tempo and 20 tracks of a similar tempo to that required for experimental testing (fast: 135 bpm; very fast: 139 bpm; see Karageorghis et al., 2011) were subjected to further assessment. A panel of 10 purposively-selected sports science students (M_{age} = 20.9 years, *SD* = 1.5 years) rated the motivational qualities of the 20 tracks using the Brunel Music Rating Inventory-3 (BMRI-3; Karageorghis, 2008). This procedure was undertaken to ensure that music used in the experimental trials was homogenous in terms of its motivational qualities (e.g., lyrical affirmations, extra-musical associations, etc), as a lack of homogeneity can present a threat to internal validity. The panel matched the profile (i.e., age and socio-cultural background) of the intended participants in the experimental trials (see Karageorghis & Terry, 1997). The panel rated the motivational qualities of each track with reference to cycling at a moderate-to-high intensity (5 out of 10 on the Borg CR10 scale [Borg, 1998]). The final music selection followed qualitative guidelines stipulated by Karageorghis et al. (2006b) in order to optimise the music selection procedure. The tempo of a track was digitally altered in instances where it was not an exact match of the required tempo. Four tracks (total duration 10 min) with similar motivational quotients from each tempi were used in Stage 2 of the present study (see Table 5.1 for track details). The BMRI-3 scores for the fast-tempo tracks (*M* = 31.25, *SD* = .51) differed from the very-fast tempo tracks (*M* = 27.83, *SD* = 1.64); $t(3) = 4.49$, $p = .021$. The statistical difference highlights the difficulty in selecting tracks that are relatively homogenous in terms of motivational quotients. Regardless of this statistical difference, the scores for the fast and very-fast tempo tracks fell within the range described by Karageorghis (2008) as being moderately motivational (24–35).

Table 5.1

Details of Music Selections used in Experimental Conditions

	Experimental music selections			
	Fast-tempo tracks (135 bpm)			
Artist	Rihanna ft Calvin Harris	Chris Brown ft Benny Benassi	Avicci	Example
Track title	We Found Love	Beautiful People	Levels	Kickstarts
Album	Talk That Talk	F.A.M.E.	-	Won't Go Quietly
Credit	Def Jam	Jive	Universal	Data
BMRI-3 Score (*M*)	31.1	32.0	30.9	31.0
	Very fast-tempo tracks (139 bpm)			
Artist	Darude	Bingo Players	Redlight	Redlight
Track title	Sandstorm	Rattle	Lost in Your Love	Get Out My Head
Album	Before the Storm	Around the Town	-	-
Credit	16 Inch	Hysteria	Polydor	Mercury Records
BMRI-3 Score (*M*)	29.4	29.0	26.9	26.0

5.2.1.2 Video selection.

5.2.1.2.1 Participants and procedure. A panel of 10 purposively selected sports science students (M_{age} = 21.2 years, SD = 1.9 years) from Brunel University evaluated three pieces of video footage using a 5-point scale according to how well it represented a pleasant rural scene (not at all, slightly, moderately, strongly or very strongly representative; Pretty et al., 2005). Attempts were made to record original footage by filming while cycling through a large local park but this was of inadequate quality. These attempts included using a bicycle with shock-absorbing suspension and mounting the camera onto the handlebars. A gyroscope was required to enable filming of high enough quality but this equipment was unavailable. Appropriate footage was downloaded from the internet and the speed of the footage was adjusted slightly to ensure a degree of congruence between participants' cadence on the ergometer and the changing environment in the video footage. The original video footage was edited to be 10 min in duration.

A criterion was set whereby 90% of the panel had to deem the footage to be at least "strongly representative" of a pleasant rural scene; this criterion was met for one video. Video filmed from a point-of-view (POV) perspective in a parkland setting was selected.

5.2.2 Stage 2: Experimental Investigation

5.2.2.1 Power analysis. To establish appropriate sample size, a power analysis was undertaken using the *as in SPSS* option within the software G*Power3 (Faul et al., 2007). Based on a medium effect size (partial $\eta^2 = 0.09$; see Study 1), an alpha level of .05 and power at .8 to protect beta at four times the level of alpha (Cohen, 1988, pp. 4-6), the analysis indicated that 30 participants would be required. An extra eight participants were recruited to protect against participant attrition and deletions due to outliers, thus a total of 38 participants were recruited.

5.2.2.2 Participants. Participants (19 women and 19 men; $M_{age} = 21.1$ years, $SD = 1.9$ years) were moderately physically active, which was defined as engaging in moderate intensity (60–75% $VO_{2\ max}$ [maximal aerobic capacity]) aerobic exercise for a minimum of 30 min at least three times a week over the previous 6 months (cf. Hutchinson & Tenenbaum, 2007).

5.2.2.3 Apparatus and measures. An electronically-braked cycle ergometer (Velotron Dynafit Pro) was used in the pre-test session as a means to establish maximum aerobic capacity. Breath-by-breath data was captured and analysed using an online gas analyser (Oxycon Pro Metabolic Cart). Ratings of perceived exertion were measured at one minute intervals throughout the pre-test protocol using the Borg CR10 scale (Borg, 1998). Heart rate was recorded at one-minute intervals throughout the protocol using a chest strap that was fitted to the participant and a receiver that was held by the researcher (Polar Accurex Plus).

An electronically-braked cycle ergometer (Velotron Dynafit Pro) was used for experimental testing along with a wall-mounted stereo system (Tascam CD-A500) and a decibel meter (AZ 8928 Sound Level Meter) to standardise music intensity at 75 dbA. This sound intensity is advised by the UK's Health and Safety Executive as below the need for individuals to wear ear protection (The Control of Noise at Work Regulations 2005). Heart rate and HRV were recorded using a three-lead electrocardiograph (ECG; ADInstruments BIOAmp CF). Video footage was played using a desktop computer connected to a projector (Mitsubishi LCD Projector XL9U). Video images were projected onto a bespoke projection screen (measuring 195 cm x 280 cm) which was situated 250 cm in front of the participant.

Affect and activation were assessed in-task and immediately post-task using the Feeling Scale (Hardy & Rejeski, 1989) and Felt Arousal Scale (Svebak & Murgatroyd, 1985). In-task measures were taken at minutes 4 and 8 during each condition. Attentional focus was assessed using Tammen's (1996) single-item Attention Scale. A 9-item shortened version of the Flow State Scale-2 (S FSS-2;

Jackson et al., 2008) as well as the Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991) was administered immediately after each condition. Music preference for each of the conditions in which music was used was assessed using a single item based on a “how do you feel right now” response set. Music preference was recorded during each of the conditions that included music and was assessed using a single item: “Based on how you feel right now, rate how much you like the music” with responses provided on a 10-point Likert scale anchored by 1 (“I do not like it at all”) and 10 (“I like it very much”; see Study 1).

5.2.2.4 Pretest and habituation. Participants were required to cycle on an ergometer at 10% of maximum capacity below ventilatory threshold and 5% of maximum capacity above ventilatory threshold during the experimental trials. The original intention was to set exercise intensities 10% above and below ventilatory threshold, but piloting of the protocol demonstrated that participants were generally unable to maintain exercise for the necessary duration at 10% above ventilatory threshold owing to excessive localised muscle fatigue.

Participants were required to complete a $VO_{2\ max}$ test on a cycle ergometer (Velotron Dynafit Pro) to establish their maximal voluntary ventilation and ventilatory threshold. The height (cm) and weight (kg) of each participant was recorded upon arrival, and each participant was fitted with a chest strap heart rate monitor (Polar Accurex Plus). Participants were then instructed to sit on the cycle ergometer and the saddle height was adjusted to ensure that the pedal crank arm was vertical when the participant’s knee was slightly flexed. The saddle and handlebar height were recorded for each individual and these were set for each subsequent experimental trial. A face-mask was then fitted to each participant and baseline resting data was collected for three minutes. The online gas analyser (Oxycon Pro

Metabolic Cart) recorded breath-by-breath data beginning with the rest period. Participants then completed a 5 min warm-up on the ergometer after which the ramp protocol to establish their VO_{2max} and ventilatory threshold began.

The cycling task, as opposed to treadmill, as a means to invoke the required exercise intensity afforded greater freedom from ECG artefacts as the participant's upper body remains relatively stationary (Wasserman, 2005). The maximal testing procedure was calculated for each individual based on Wasserman's (2005) method and designed so that each participant would peak at approximately 10 min. The British Association of Sport and Exercise Sciences (BASES) suggest that exhaustion should be attained within 9-15 min of commencing a maximal protocol (BASES, 2006). The initial stage of Wasserman's method is to calculate an unloaded pedalling estimate (ml/min) by using the formula: 150 + (6 x weight in kg). The second stage is to calculate peak VO_2, which for males was estimated using the formula: Peak VO_2 = (Height in cm – Age) x 20. For females, the formula used was: Peak VO_2 = (Height in cm – Age) x 14. The final stage calculates work rate increment (watts/min) using: (Peak VO_2 – Unloaded VO_2)/100. Figure 5.3 shows an example of a ramp protocol for a 21-year-old male participant (height = 180 cm, weight = 75 kg).

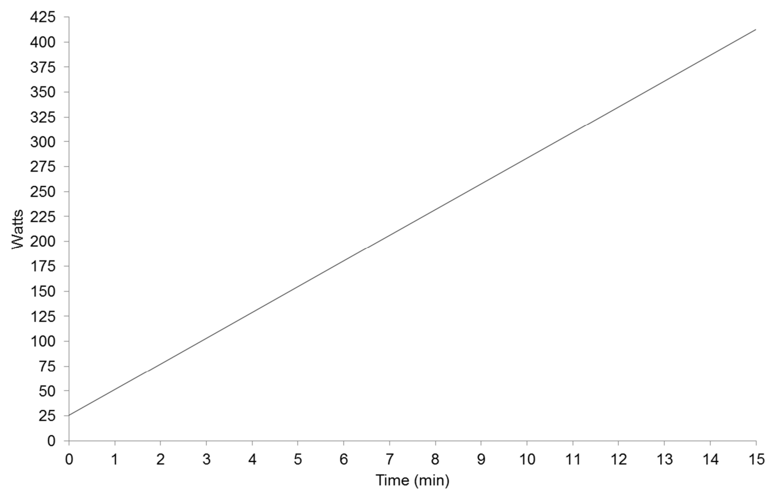

Figure 5.3. Example of test protocol using Wasserman's method (data based on a 21-year-old male; height = 180 cm; weight = 75 kg).

This method calculates a workrate based on data collected from sedentary participants, therefore it is expected that participants in the proposed study will take longer than 10-min to complete the protocol owing to their pre-existing level of physical fitness. The Wasserman method calculates wattage for one minute stages, however, the protocol was administered with the wattage continually increasing. For example, if the calculation dictated that the wattage at minute 7 was 150W and the wattage at minute 8 was 175W, the wattage increased at a rate of 0.42W per second. Participants cycled at a cadence of 75 ± 3 rpm. This continual increase in wattage allows for greater accuracy with which to set workloads during the experimental trials.

In accordance with the BASES physiological testing guidelines (2006), each participant was monitored with regard to the following criteria during the maximal test: a plateau in the oxygen uptake/exercise intensity relationship; a final respiratory exchange ratio of 1.15 or above; a final heart rate within 10 bpm of their age-related maximum, subjective fatigue or volitional exhaustion, and a "10" (*Extremely Strong*) on the Borg CR10 scale (Borg, 1998). Participants are thought to have exercised to exhaustion when they meet these criteria.

The highest level of oxygen uptake averaged over 20 s was designated as VO_{2max}. The ventilatory threshold was identified offline using Winbreak software (Ekkekakis, Lind, Hall, & Petruzzello, 2008) based on the three-method procedure described by Gaskill et al. (2001). The wattage to be set on the cycle ergometer during the experimental trials was determined by plotting power against VO_2 from each participant's pre-test data and interpolating the target wattage corresponding with 10% of maximum capacity below ventilatory threshold and 5% of maximum capacity above for each participant.

A habituation session followed the pretest and participants were familiarised with the specifics of the experimental trial. Each participant had the procedure explained to them and was afforded an opportunity to ask questions. Participants completed the Attentional Focusing Questionnaire (Brewer et al., 1996) in order to ascertain their preferred attentional style (see Study 2).

5.2.2.5 Experimental trial. There were three experimental conditions (music-only, video-only, and music-and-video) and one control condition (no music and visually sterile) at 10% of maximum capacity below ventilatory threshold and 5% of maximum capacity above (eight conditions in total). During the music-only condition, participants were exposed to a 10-min music playlist while immersed in a visually sterile environment (sound level intensity standardised at 75 dBA). During the video-only condition, participants were exposed to a 10-min video showing POV footage recorded in a parkland setting from a cycle route and there was no audio accompaniment (i.e., sounds of the parkland environment) to the footage. During the music-and-video condition, each participant was exposed to a 10-min music playlist and observed the POV video footage.

Participants were given an opportunity to stretch before each session. Each participant was required to wear a heart rate monitor (Polar Accurex Plus) when they first entered the laboratory for each testing session. Following a 2-min period of rest, the participant's heart rate was recorded and used as a resting value. Three electrodes were then attached to each participant (see Figure 5.4). In-task HRV data and HR data was recorded by a computer situated on Table A. Each trial began with a warm-up on the ergometer (75 ± 3 rpm for 5 min). The cycle ergometer was connected to a computer station (Table B) and in-task pedal cadence was monitored from there. The electronically-braked ergometer was then set at the appropriate resistance (Watts) to correspond with either 10% of maximum capacity below ventilatory threshold or 5% above as calculated using each participant's pre-test data. Cadence was standardised at 75±3 rpm to prevent auditory-motor synchronisation with music tempo (135 bpm or 139 bpm). Workload was not altered according to HR during the conditions as this would have invalidated the HRV data owing to the change in physiological demands of the task.

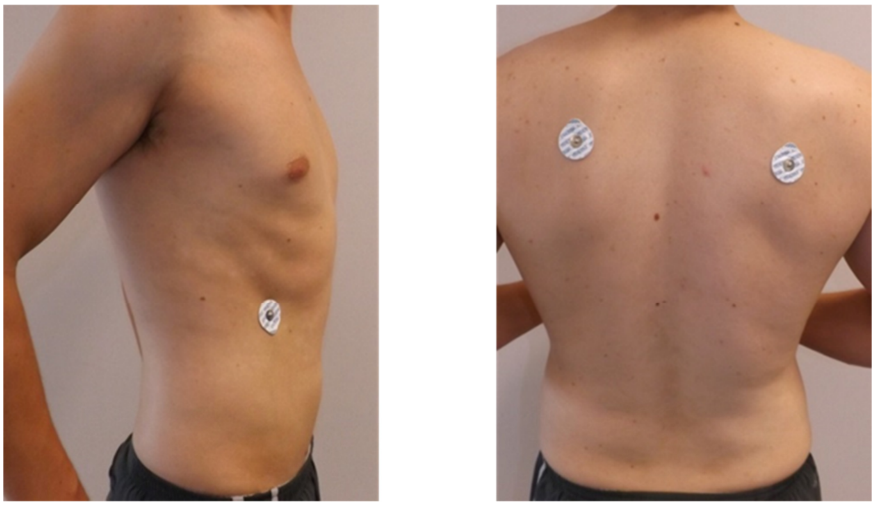

Figure 5.4. Participant with ECG electrodes in preparation for HRV data recording.

Each participant was administered the Feeling Scale and Felt Arousal Scale after 4 min and 8 min of each condition. At 10 s before the end of each condition that included music, participants were asked to rate their collective preference for the music selections they had just heard. The participant dismounted the ergometer at the end of each condition and completed the post-task measures (State attention item, Feeling Scale, Felt Arousal Scale, S FSS-2, and PACES) while seated at a nearby desk.

Two conditions were administered in each testing session separated by a rest period. Participants were required to complete questionnaires after the first condition and then to rest until their heart rate returned to within 10% of their resting value at which point they would rest for a further 2 min before commencing the second condition. The order of conditions was randomised to minimise potential order and learning effects. It was not possible to fully counterbalance the design (between and within conditions; Harris, 2008, p. 136) as there was an insufficient number of participants (40,320 participants would have been required). Participants did not complete two conditions at the same intensity within a single visit (i.e., completed a condition at 10% below VT and then 5% above VT or vice versa). Further, participants did not hear the same music selection twice within a session. Each participant visited the laboratory on five occasions (one pretest and habituation session, and four testing sessions) and each session lasted no longer than 45 min.

Participants were requested to follow similar patterns of activity (including no vigorous physical activity) and diet on the day before and of each experimental trial (Harris, 2008, p. 134). Each participant engaged in the trials individually. The experimental trials were scheduled at the same time of day for each participant over a 4-week period, with a minimum of 3 days between each trial. Figure 5.5 shows a participant during a condition that included video footage.

Figure 5.5. A participant during a condition that included video

5.2.3 Data Analysis

Using PASW Statistics 18, data were screened for outliers and tested for the parametric assumptions underlying mixed-model ANOVA and MANOVA. Affective variables (in-task and post-task Feeling Scale and Felt Arousal scores) were assessed using a mixed-model 4 x 2 x 2 (Condition x Exercise Intensity x Sex) MANOVA. Attentional focus was assessed using a mixed 4 x 2 x 2 ANOVA. Motivation variables (S FSS-2 and PACES scores) and HRV high and low frequency normalised power were analysed using mixed-model 4 x 2 x 2 MANOVAs. HRV ratio data were analysed using a mixed-model 4 x 2 x 2 ANOVA. Music preference ratings were employed as a manipulation check and these were analysed using a 2 x 2 (Condition x Exercise Intensity) ANOVA. Heart rate was employed as a manipulation check to ensure a significant difference in physiological workload between intensities and was assessed using a paired samples t-test.

5.3 Results

Four male participants did not complete the protocol and are not included in the analyses presented herein. Prior to submitting the data set for analysis, item level data were checked for univariate and multivariate outliers. Checks for univariate outliers using *z* scores revealed 41 cases outside the acceptable range (±2.58).Ten of these outliers were associated with LF/HF ratio data and were related to other HRV outliers (HF or LF) within the same condition. The ratio data was not modified as this would change as a consequence of modifying the related HF or LF data within the same condition. The remaining 31 outliers were modified to within one unit of the nearest score. The ratio data was subsequently recalculated and a second screening of univariate outliers was conducted. The second round of screening revealed 23 cases outside the acceptable range. Of these 23 outliers, 11 were associated with HRV ratio variables and the decision was taken not to modify these raw scores but to modify the associated HF or LF outlier and the ratio would alter as a consequence. Twelve modifications took place following the second screening for univariate outliers. A third round of screening revealed 13 cells outside the acceptable range. Of these 13 outliers, 5 were associated with HRV and the decision was taken not to modify these ratio data similar to previous stages. Eight modifications took place following the third round of screening. A fourth check for univariate outliers revealed no cells outside the range ±2.58. Checks for multivariate outliers revealed no outliers.

Tests of the distributional properties of the data in each analysis cell revealed violations of normality in 12 of the 184 cells (all at $p < .05$). Six of these violations indicated mild positive skewness in the HRV ratio variable and the decision was taken to apply square root transformation to this data (Tabachnick & Fidell, 2007, pp. 86–88). The transformation was successful in normalising the HRV ratio data and only minor violation of normality remained in 6 cells of the 184 for analysis (3%). Tabachnick and Fidell suggest that *F* test is sufficiently robust to withstand such minor violation of normality. Mauchly's test indicated six instances in which the sphericity assumption was violated therefore Greenhouse-Geisser adjustments were made to the relevant *F* tests. Collectively, the diagnostic tests indicated that the assumptions underlying MANOVA and ANOVA were satisfactorily met.

A Cognitive Index (CI; Masters & Ogles, 1998) was determined for each participant ($n = 34$) to enable analysis by attentional style. Masters and Ogles suggested that this provided a method by which to evaluate preference (not absolute levels) for an attentional strategy. The AFQ CI scores were intended to be used as a covariate in the analysis of state attention in order to minimise the influence of dominant attentional style on this related dependent variable. However, this was not actualised as the AFQ CI scores did not satisfactorily meet the assumptions underlying covariate analysis. Specifically, the data were normally distributed, satisfied homogeneity of variance, and were adequately reliable; however, data were non-linear, and demonstrated heterogeneity of regression (Tabachnick & Fidell, 2007, pp. 200–203).

5.3.1 Manipulation Checks

The manipulation check for music preference ratings revealed no Condition x Intensity interaction, $F(1, 33) = .10$, $p = .752$, $\eta_p^2 = .00$. There was no main effect for condition, $F(1, 33) = .02$, $p = .889$, $\eta_p^2 = .00$, but there was a main effect for intensity, $F(1, 33) = 7.69$, $p = .009$, $\eta_p^2 = .19$, showing that participants generally preferred music at the low intensity (see Table 5.2) and that this was associated with a large effect size.

Table 5.2

Descriptive statistics for post-task music preference ratings across conditions

Condition	*M*	*SD*
AB NV A2	7.24	1.78
AB V A2	7.21	1.89
BE NV A1	7.97	1.03
BE V A1	8.06	1.25

Note. AB = 5% above VT, BE = 10% below VT, NV = No video, V = Video, A2 = Music playlist 2, A1 = Music playlist 1.

The manipulation check for heart rate revealed a significant difference between the 10% below ventilatory threshold and 5% above intensities; $t(33) = 15.95$, $p < .001$. The average heart rate recorded during the 10% below ventilatory threshold conditions was *M* = 131.87 bpm, *SD* = 13.47. This compared to *M* = 150.44 bpm, *SD* = 12.06 for conditions 5% above ventilatory threshold. Table 5.3 includes descriptive data for heart rates recorded during each condition. The highest mean heart rate was recorded during the combined music and video condition during the above VT intensity, while the lowest was recorded for the video only condition during the below VT exercise intensity.

Table 5.3

Descriptive statistics for heart rate across all conditions

Condition	*M*	*SD*
AB NV A2	147.70	16.91
AB V A2	151.24	13.06
AB V NA	152.14	13.94
AB NV NA	150.70	13.13
BE NV A1	133.98	16.36
BE V A1	132.73	16.06
BE V NA	128.71	15.67
BE NV NA	132.07	15.10

Note. AB = 5% above VT, BE = 10% below VT, NV = No video, V = Video, A2 = Music playlist 2, A1 = Music playlist 1, NA = No music.

The average resistance on the cycle ergometer was 129 W for males and 79 W for females during the 10% below VT conditions. There was an average increase of 51 W between the 10% below and 5% above VT intensities for males with an average of 180 W at the higher intensity. There was an increase of 36 W for females with an average of 115 W during the above VT intensity compared to the lower intensity.

5.3.2 Affective Variables

There were no interaction effects for the affective variables (see Table 5.4). There were significant main effects for condition and intensity (see Table 5.4 and Figure 5.6, Figure 5.7, and Figure 5.8). Step-down *F* tests for condition exhibited significant differences for in-task affect: $F(2.01, 64.41) = 46.99$, $p < .001$, $\eta_p^2 = .60$; post-task affect, $F(3, 96) = 35.36$, $p < .001$, $\eta_p^2 = .53$; in-task perceived activation $F(2.27, 72.78) = 28.80$, $p < .001$, $\eta_p^2 = .47$; post-task perceived activation $F(1.96, 62.86) = 35.33$, $p < .001$, $\eta_p^2 = .53$. Similar step-down *F* tests for intensity exhibited significant differences for in-task affect: $F(1, 32) = 40.00$, $p < .001$, $\eta_p^2 = .56$; and post-task affect, $F(1, 32) = 42.94$, $p < .001$, $\eta_p^2 = .57$. However, there were no significant differences for in-task perceived activation $F(1, 32) = 2.09$, $p = .158$, $\eta_p^2 = .06$; post-task perceived activation $F(1, 32) = .20$, $p = .659$, $\eta_p^2 = .01$.

Pairwise comparisons for in-task affective valence indicated that the music-only and music-and-video conditions differed from both the video-only (95% CI = 0.595–1.494, $p < .001$; 95% CI = 0.547–1.379, $p < .001$) and control conditions (95% CI = 1.008–2.148, $p < .001$; 95% CI = 1.084–1.907, $p < .001$). Moreover, the video-only condition differed from control (95% CI .087–.979, $p = .012$). Pairwise comparisons for post-task affective valence revealed a similar pattern of differences, with the exception that there was no difference between video-only and control (95% CI = 0.724–1.999, $p < .001$; 95% CI = 0.607–1.819, $p < .001$; 95% CI = 1.085–2.336, $p < .001$; 95% CI = 1.001–2.124, $p < .001$). Pairwise comparisons indicated that in-task affective valence was more positive at 10% below ventilatory threshold than it was at 5% above (95% CI = 0.899–1.713, $p < .001$), and post-task valence demonstrated an identical trend (95% CI = 1.126–2.142, $p < .001$). Pairwise comparisons for in-task perceived activation indicated that the music-only and the music-and-video conditions yielded higher levels of activation than the video-only (95% CI = 0.354–1.072, $p < .001$; 95% CI = 0.428–1.084, $p < .001$) and control conditions (95% CI = 0.502–1.459, $p < .001$; 95% CI = 0.580–1.467, $p < .001$). The post-task perceived activation measures indicated an identical trend (95% CI = 0.348–1.385, $p < .001$; 95% CI = 0.473–1.379, $p < .001$; 95% CI = 0.720–1.747, $p < .001$; 95% CI = 0.871–1.715, $p < .001$) and also the video-only condition elicited higher levels of activation than the control condition (95% CI = 0.064–0.669, $p = .011$).

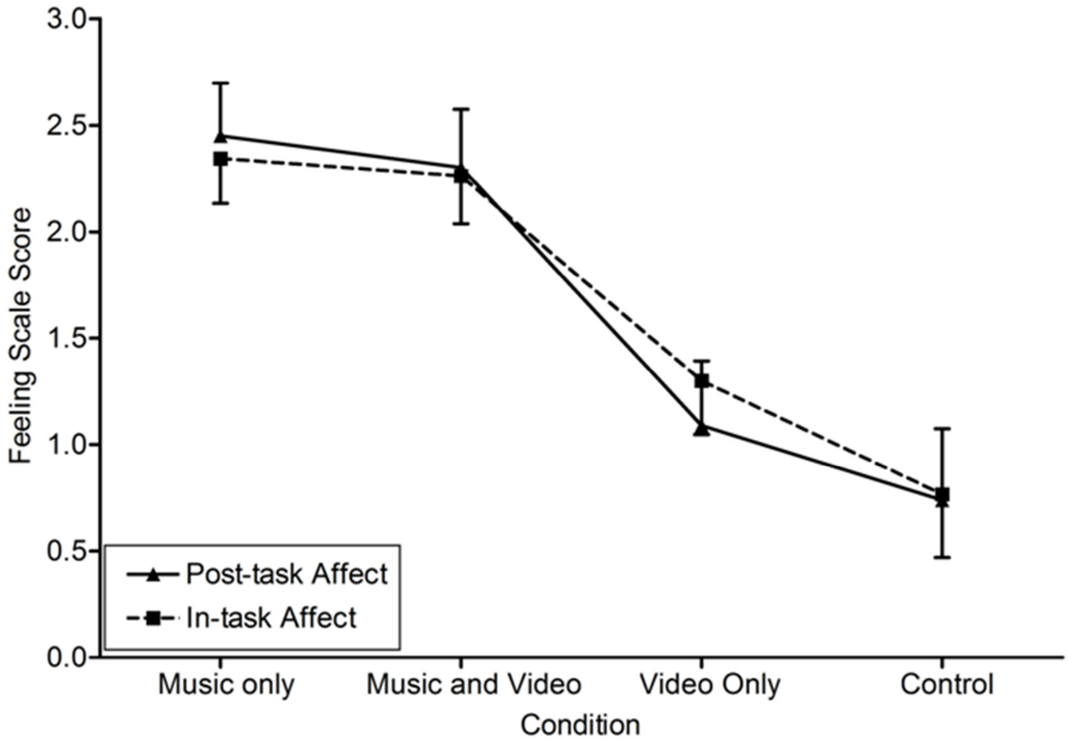

Figure 5.6. Feeling Scale means and standard errors (T-bars) across conditions.

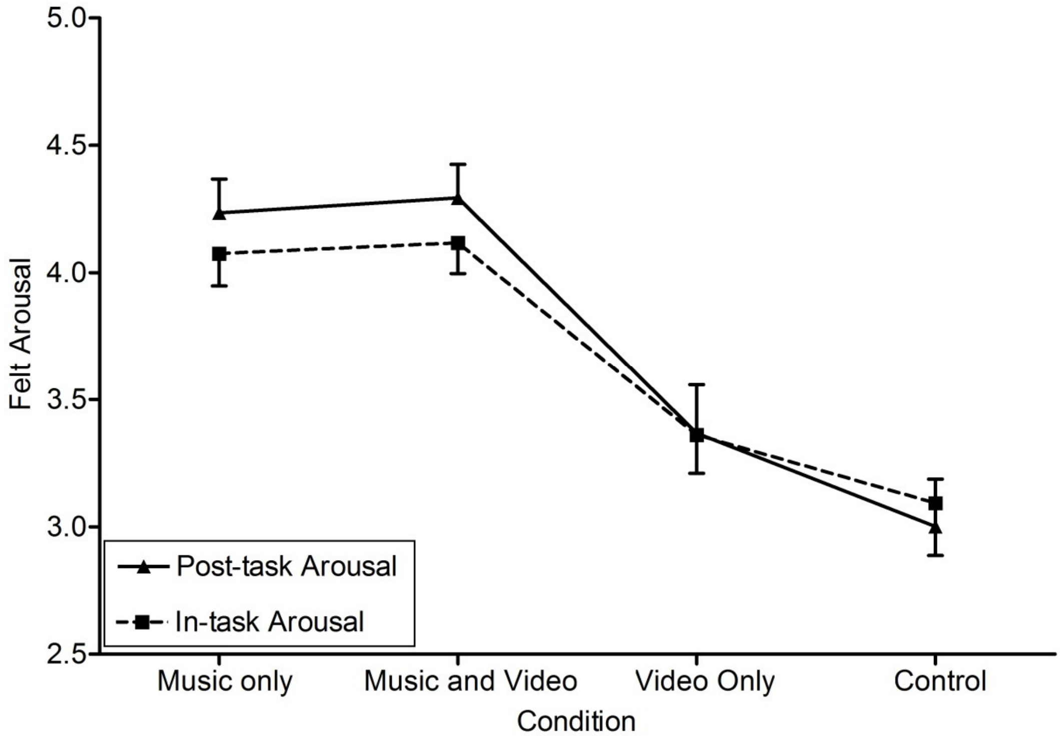

Figure 5.7. Felt Arousal Scale means and standard errors (T-bars) across conditions.

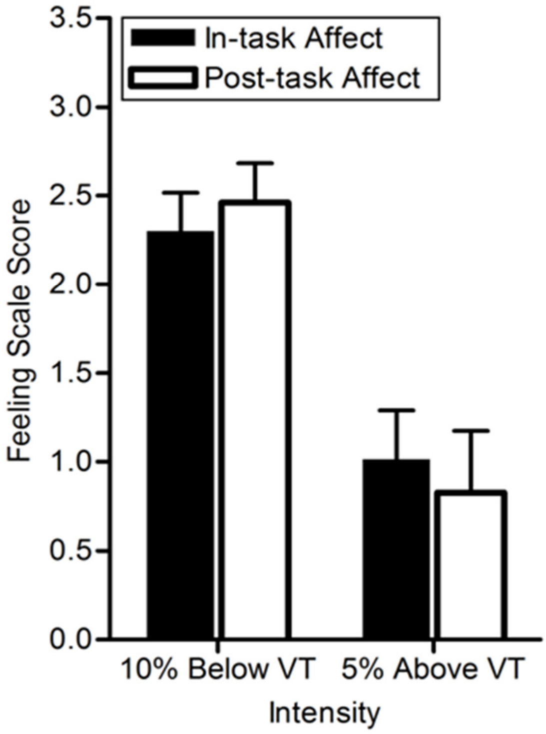

Figure 5.8. Feeling Scale means and standard errors (T-bars) across intensities.

5.3.3 State Attention

There were no interaction effects for the state attention variable (see Table 5.4). There were significant main effects for condition and intensity (see Table 5.4 and Figure 5.9). Pairwise comparisons for state attention indicated that the music-and-video condition promoted a greater number of dissociative thoughts when compared to the remaining three conditions ($p < .05$). Pairwise comparisons also revealed a higher number of dissociative thoughts in the 10% below ventilatory threshold condition when compared to the 5% above ventilatory threshold condition (95% CI = 17.701–32.392, $p < .001$). The results for each condition have been visualised alongside the predicted state attention results presented earlier (see Figure 5.10).

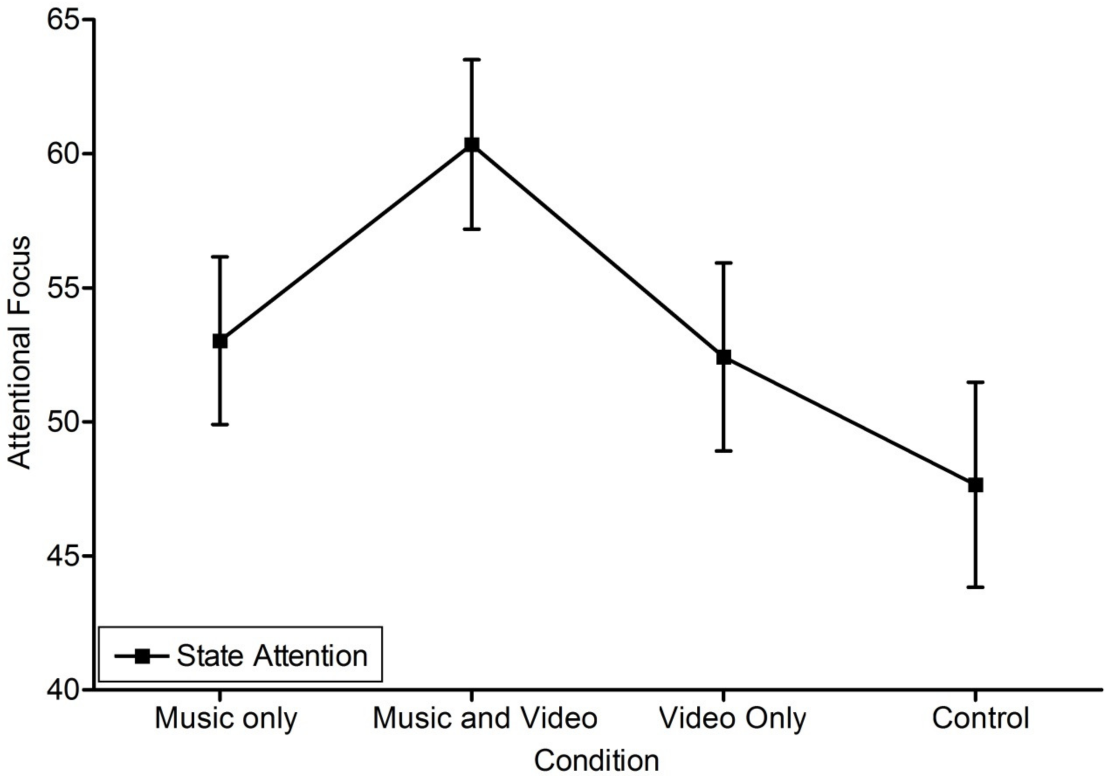

Figure 5.9. State attention means and standard errors (T-bars) across conditions.

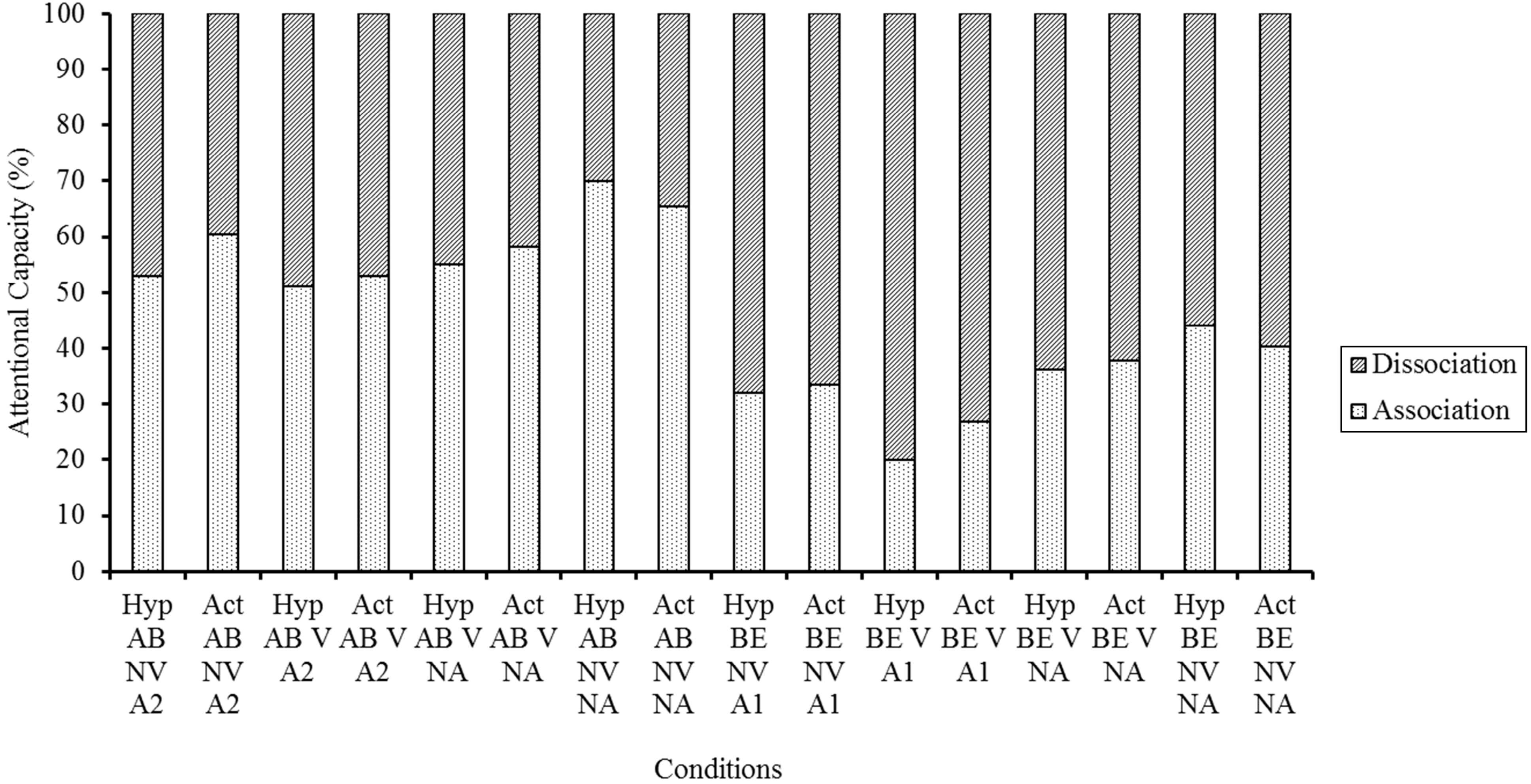

Figure 5.10. Comparison of hypothesised and actual state attention results across all conditions. Hyp = Hypothesised, Act = Actual, AB = 5% above VT, BE = 10% below VT, NV = No video, V = Video, A2 = Music playlist 2, A1 = Music playlist 1.

5.3.4 Motivation Variables

There were no interaction effects for the motivation variables (see Table 5.4). There were significant main effects for condition and intensity (see Table 5.4 and Figure 5.11). Step-down *F* tests for condition exhibited significant differences for flow: $F(2.12, 67.86) = 22.32$, $p < .001$, $\eta_p^2 = .41$; and PACES: $F(3, 96) = 28.80$, $p < .001$, $\eta_p^2 = .47$ that were associated with large effect sizes. Similar step-down *F* tests for intensity exhibited significant differences for flow: $F(1, 32) = 25.08$, $p < .001$, $\eta_p^2 = .44$; and PACES: $F(1, 32) = 16.58$, $p < .001$, $\eta_p^2 = .34$. Pairwise comparisons for flow indicated higher levels in the music-only and music-and-video conditions when compared to the video-only (95% CI = 0.054–0.506, $p = .009$; 95% CI = 0.113–0.500, $p < .001$) and control conditions (95% CI = 0.225–0.598, $p < .001$; 95% CI = 0.254–0.621, $p < .001$). Pairwise comparisons indicated higher flow state scores at 10% below ventilatory threshold when compared to 5% above ventilatory threshold (95% CI = 0.136–0.323, $p < .001$).

Pairwise comparisons indicated that participants experienced greater exercise enjoyment in the music-only condition and music-and-video conditions when compared to the video-only (95% CI = 6.020–22.624, $p < .001$; 95% CI = 6.440–21.326, $p < .001$) and control conditions (95% CI = 11.454–27.157, $p < .001$; 95% CI = 11.330–26.404, $p < .001$). Pairwise comparisons also indicated that participants experienced greater exercise enjoyment at 10% below ventilatory threshold when compared to 5% above ventilatory threshold (95% CI = 3.629–10.898, $p < .001$).

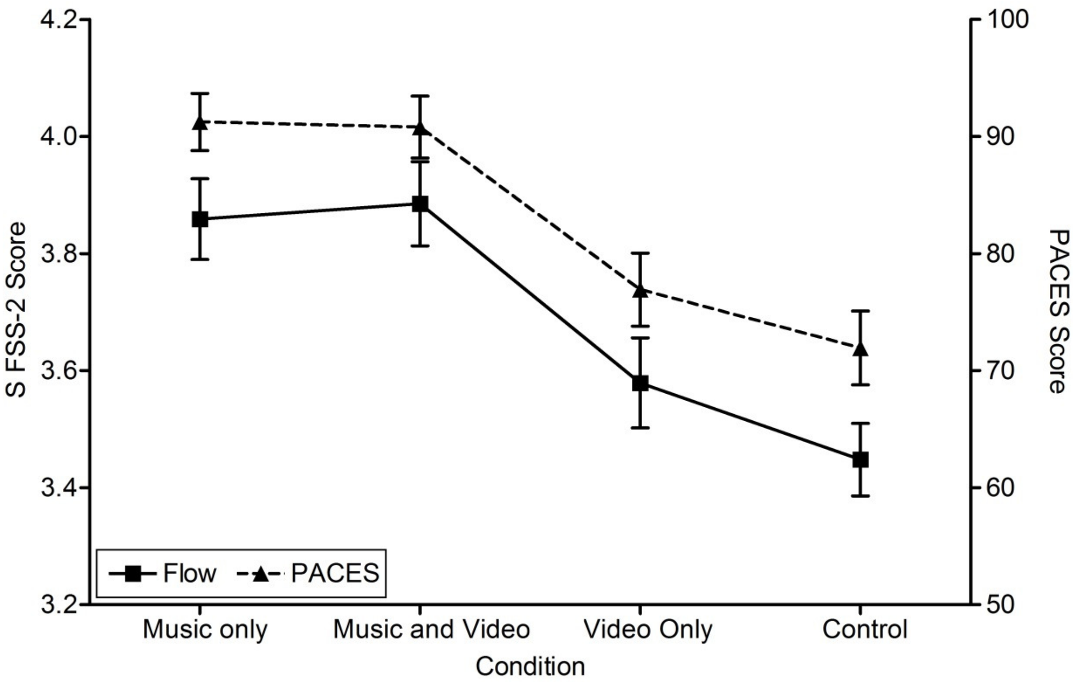

Figure 5.11. S FSS-2 and PACES means and standard errors (T-bars) across conditions.

5.3.5 Heart Rate Variability Ratio

There was a significant Intensity x Sex interaction for HRV ratio (see Table 5.4 and Figure 5.12). An examination of means and standard errors indicated that although females LF/HF ratio remained relatively stable across exercise intensities, males exhibited a sharp decline in the ratio from 10% below ventilatory threshold to 5% above. There was a significant main effect for condition (see Table 5.4 and Figure 5.13). Pairwise comparisons for the LF/HF ratio indicated a higher ratio in the video-only condition when compared to the other three conditions (all at $p < .05$).

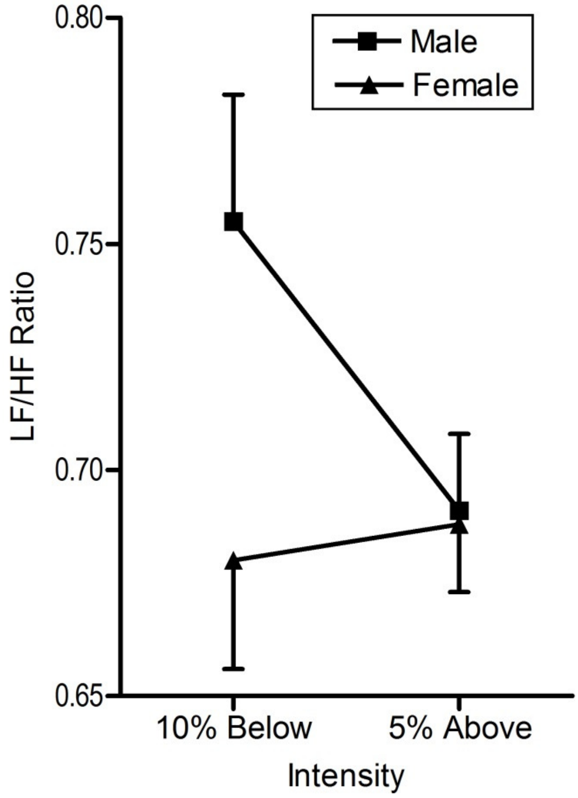

Figure 5.12. Significant Intensity x Sex interaction for HRV LF and HF.

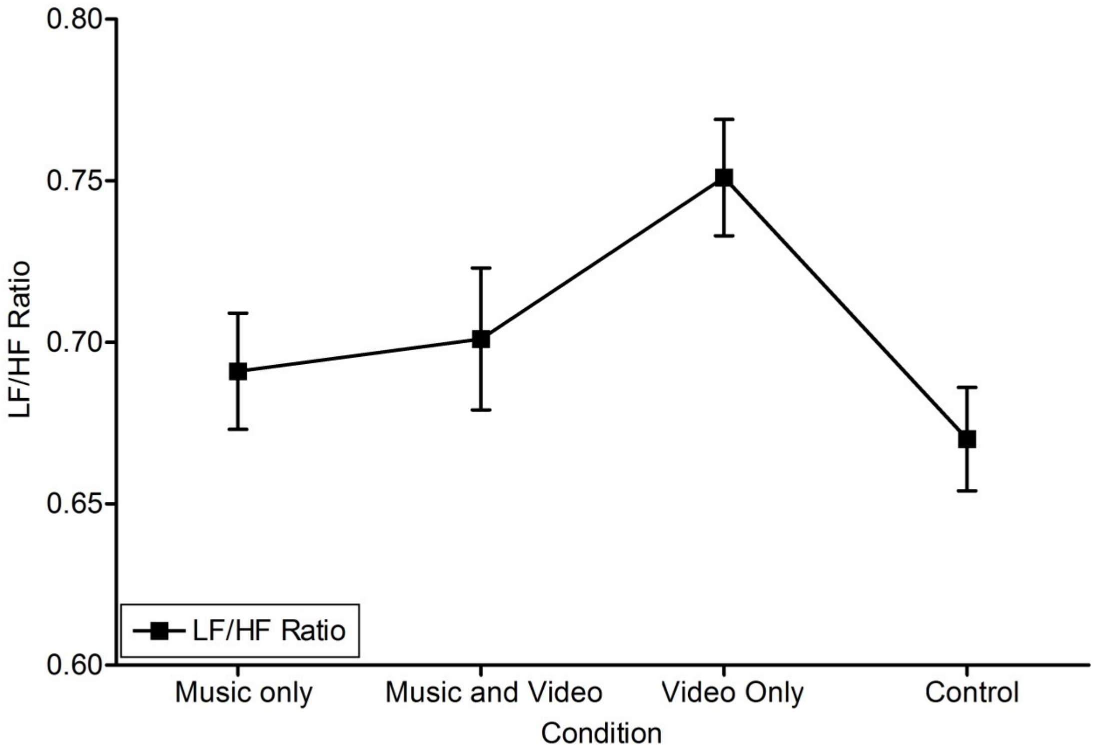

Figure 5.13. HRV ratio means and standard errors across conditions.

5.3.6 Heart Rate Variability LF/HF

There were no interaction effects for the HRV LF/HF variables (see Table 5.4). There were significant main effects for condition and intensity (see Table 5.4, Figure 5.14, and Figure 5.15). Step-down *F* tests for condition exhibited significant differences for HRV LF: $F(3, 96) = 6.68$, $p < .001$, $\eta_p^2 = .17$; but no significant differences for HRV HF: $F(3, 96) = 1.12$, $p = .346$, $\eta_p^2 = .03$. Step-down *F* tests for intensity exhibited significant differences for HRV LF: $F(1, 32) = 8.19$, $p = .007$, $\eta_p^2 = .20$; but not for HRV HF: $F(1, 32) = 2.45$, $p = .127$, $\eta_p^2 = .07$. Pairwise comparisons for LF normalised power indicated higher normalised power in the video-only condition when compared against the other three conditions (all at $p < .05$). Pairwise comparisons indicated greater LF normalised power at 10% below ventilatory threshold when compared to 5% above ventilatory threshold (95% CI = .398–2.363, $p = .007$).

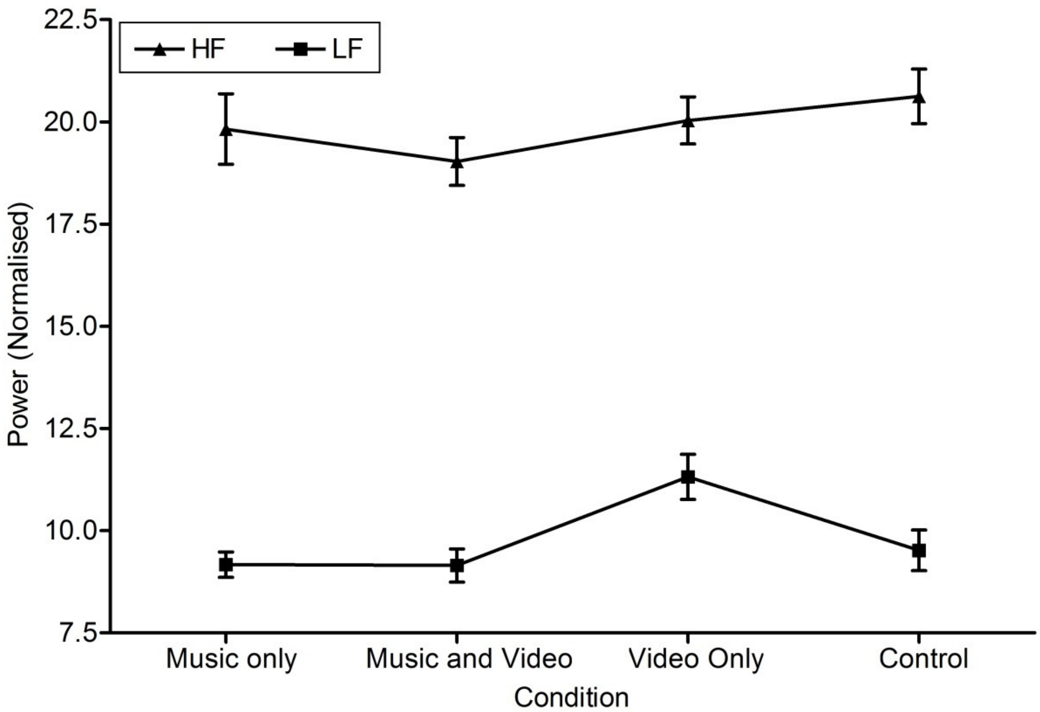

Figure 5.14. HRV LF and HF means and standard errors across conditions.

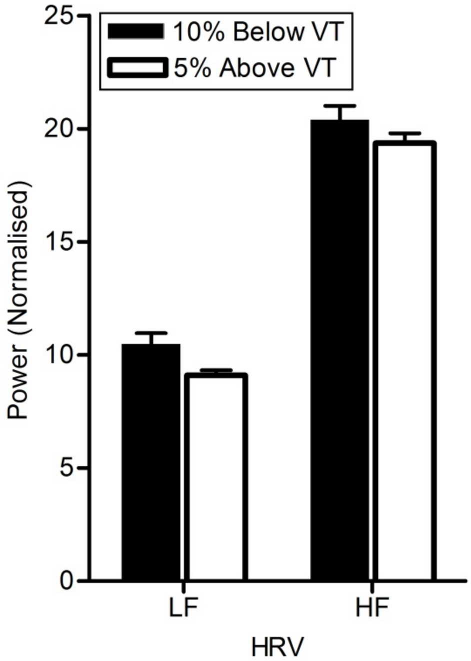

Figure 5.15. HRV LF and HF means and standard errors across intensities.

Table 5.4

Inferential Statistics Results for all Dependent Variables

	Pillai's Trace	*F*	*df*	*p*	η_p^2
Interaction effects					
Affective variables					
Condition x Exercise Intensity x Sex	.16	1.31	12, 285	.213	.05
Condition x Sex	.13	1.10	12, 285	.358	.04
Exercise Intensity x Sex	.10	.79	12, 285	.660	.03
Condition x Exercise Intensity	.14	1.18	4, 29	.343	.14
State attention					
Condition x Exercise Intensity x Sex		.67	3, 96	.573	.02
Condition x Sex		.48	3, 96	.699	.02
Exercise Intensity x Sex		.86	1, 96	.362	.03
Condition x Exercise Intensity		.33	3, 96	.807	.02
Motivation variables					
Condition x Exercise Intensity x Sex	.07	1.11	6, 192	.361	.03
Condition x Sex	.11	1.90	6, 192	.083	.06
Exercise Intensity x Sex	.15	2.71	2, 31	.082	.15
Condition x Exercise Intensity	.05	.85	6, 192	.530	.03
HRV LF/HF					
Condition x Exercise Intensity x Sex	.11	1.81	6, 192	.099	.05
Condition x Sex	.05	.81	6, 192	.566	.03
Exercise Intensity x Sex	.12	2.14	2, 31	.135	.12
Condition x Exercise Intensity	.06	1.05	6, 192	.397	.03
HRV Ratio					
Condition x Exercise Intensity x Sex		2.08	3, 96	.107	.06
Condition x Sex		1.21	3, 96	.312	.04
Exercise Intensity x Sex		4.58	1, 96	.040	.13
Condition x Exercise Intensity		1.57	3, 96	.202	.05
Main Effects					
Affective variables					
Condition	.69	7.10	12, 285	.000	.23
Intensity	.62	11.75	4, 29	.000	.62
Sex		.04	1, 2	.853	.00
State attention					
Condition		3.45	3, 96	.027	.10
Intensity		48.24	1, 32	.000	.60
Sex		.67	1, 32	.419	.02
Motivation variables					
Condition	.50	10.79	6, 192	.000	.25
Intensity	.45	12.58	2, 31	.000	.45
Sex		.71	2, 31	.501	.04
HRV LF/HF					
Condition	.23	4.05	6, 192	.001	.11
Intensity	.20	3.97	2, 31	.029	.20
Sex		3.97	6, 27	.029	.20
HRV Ratio					
Condition		5.05	3, 96	.003	.14
Intensity		2.85	1, 32	.101	.08
Sex		2.29	1, 32	.140	.07

Note. HRV denotes heart rate variability. LF denotes low frequency power. HF denotes high frequency power.

5.4 Discussion

The main purpose of this study was to explore the effects of auditory and visual stimuli on a range of subjective and objective measures during stationary cycling below and above the ventilatory threshold. The in-task affect data exhibited a similar trend to the post-task affect data across conditions (see Figure 5.6). No differences were exhibited between in-task and post-task affect for exercise conducted at 10% below ventilatory threshold and this trend held for 5% above the threshold. Overall the music-only and music-and-video conditions exhibited the highest scores for affective valence and this finding provides partial support for the first research hypothesis. The hypothesis that the music-and-video condition would yield the most positive affective valence responses is not supported by the present data, given that it does not differ from the music-only condition. Moreover, it appears that participants derived just as much affective benefit from music-and-video and music-only during high-exercise intensity (see Figure 5.6).

This pattern of findings was replicated in the perceived activation variable wherein there was no difference in-task to post-task measures. However, contrary to the affect data, perceived activation did not differ between exercise intensities. Thus it appears that a ceiling effect was reached for perceived activation at the lower exercise intensity albeit that both the music-and-video and the music-only conditions were effective in elevating perceived activation relative to the remaining conditions (see Figure 5.7). The video condition did not differ from control and it is plausible that the video condition did not offer sufficient stimulation; there may have been a mismatch between the level of situation-demanded activation (high) and the stimulative qualities of the video (low).

The state attention data indicate that the music-and-video condition resulted in the greatest number of dissociative thoughts at both exercise intensities (see Figure 5.9). Contrary to the research hypothesis, the music-only and video-only conditions did not differ from the control condition at either intensity. Moreover, the expected Condition x Intensity interaction did not emerge, showing that the two levels of exercise intensity had no moderating influence on attentional focus across the four conditions. As expected, there was a strong tendency toward association at the high exercise intensity with a mean difference of 26 units between the low and high exercise intensities, and this latter finding mirrors those of related studies (e.g., Study 1; Hutchinson & Tenenbaum, 2007).

Although there was a non-significant condition x intensity interaction for state attention, the pattern of the results was similar to the prediction. Figure 5.10 presents the hypothesised and observed state attention data. There were only minor differences in the predicted and observed results for conditions in the higher exercise intensity; participants did not dissociate as much as expected during the music only condition and they dissociated to a greater extent than expected in the control condition. There were few differences between the hypothesised and actual responses during conditions at the lower exercise intensity. Participants did not dissociate to the extent predicted during the music and video condition. The amount of dissociation between the music only and music and video combined condition was similar and hints at a *ceiling effect* with regards to the amount of dissociation that is possible during exercise at these intensities. It raises an interesting question of whether higher levels of dissociation could possibly be achieved at lower levels of exercise intensity and if there is any intensity, above rest, where dissociation can near 100%.

The findings for flow across conditions (see Figure 5.11) followed similar patterns to affect and attentional focus whereby a Condition x Intensity interaction did not emerge. Nonetheless, the main effect for intensity indicated a small but statistically significant difference in flow, wherein participants experienced more flow in the low-intensity conditions. This higher level of flow may indicate that participants felt the balance between challenge of the task and their competencies was optimal at the lower intensity. The PACES findings exhibited an identical pattern to those of flow; at both exercise intensities participants appeared to derive the greatest enjoyment in the music-only and music-and-video conditions.

Taken collectively, the present findings highlight the utility of music and music-and-video stimuli as a means by which to distract and enhance the psychological state of exercise participants. These positive effects amplify those found in previous related studies (e.g., Annesi, 2001; Barwood et al., 2009; Loizou & Karageorghis, 2009). A strong pattern to emerge in the findings pertains to the non-differentiation between music-only and music-and-video in terms of the range of dependent measures that were used and that contrary to the research hypothesis, exercise intensity did not moderate the benefits that participants derived from the experimental manipulations. Ostensibly, the application of music-only and music-and-video proved equally effective at exercise intensities of 10% below and 5% above ventilatory threshold. What does appear to be slightly surprising is the relative ineffectiveness of the video-only condition across all dependent variables with the exception of HRV, exposure to a video-only condition did not enhance participants' responses relative to control. This finding might suggest that visual images of the sort employed (pleasant parkland) do not tap the sensory pathways to the same degree as when used in combination with music. An alternative explanation concerns the unfamiliar nature of viewing parkland footage without an accompanying soundtrack. If comparable tasks had been conducted in an outdoor environment with auditory deprivation, it would be interesting to gauge how the presence of similar visual stimuli influences participants' responses. Further, the music was selected owing to its motivational qualities for an exercise context whereas the video was not selected with such qualities in mind, as there is no comparable guiding framework to draw upon. The parkland video footage was selected with the premise that it would confer some psychological benefit (cf. Hartig et al., 2001), but there may have been some disparity between the motivational qualities of the music and that of the video.

The dual-mode model (Ekkekakis, 2003) suggests that affective responses beyond respiratory compensation point (RCP) decline sharply, but between ventilatory threshold and RCP is scope for some variability given that some people exhibit enhanced affect while others exhibit the converse. The upper exercise intensity employed in the present study was set in the "zone of response variability" and results indicate that the music-only and music-and-video condition positively shaped affective responses in this zone. Therefore, music-only and music-and-video conditions are influential in terms of enhancing affective valence at a point beyond the ventilatory threshold. It has been suggested that during the early stages of participation, physical activity is "…unlikely to be construed as inherently pleasurable or enjoyable" (Wilson, Rodgers, Blanchard, & Gessell, 2003, p. 2375). This is recognised as one of the major barriers to exercise initiation and adherence (American College of Sports Medicine, 2013). Set against this background, the present results have significant implications. The present results demonstrate that, even when the intensity reaches this level, the decline in pleasure may not be entirely unavoidable, as it can be meaningfully tempered by the use of music and the combination of music and video.

In relation to the posits of the dual-task theory, it appears that the auditory and visual stimuli could be processed with equal effectiveness at both moderate and high exercise intensities. It was expected that there would be less processing capacity for external stimuli at the high exercise intensity, but the present data do not show any evidence of this. This finding may be attributable to the fact that both music and video constitute primarily a passive form of attentional manipulation and if one of the stimuli entailed active manipulation (e.g., mental arithmetic) the results may have been different (cf. Johnson & Siegel, 1987). This leads the way toward related protocols that feature both passive and active forms of attentional manipulation during exercise (e.g., mental recall vs. music listening). A further plausible explanation for the lack of difference in psychological response between the two intensities is that music combined with video is a common modality of exercise-related entertainment which means that the two activities can be intertwined with relatively little conscious effort required from participants. In relation to this, the video-only condition prompted weaker psychological and psychophysiological responses and this may be attributable to the use of a visual modality that is most often combined with audio in real-life settings.

The HRV findings led to the rejection of the first research hypothesis, as the music-and-video condition did not lead to significant differences compared to the other conditions. The significant main effect regarding the high- and low-frequency data for intensity is consistent with Perini and Veicsteinas's (2003) findings wherein low-frequency power was reduced as exercise intensity increased. There was also a significant Intensity x Sex interaction wherein males exhibited a sharp decline in

LF/HF ratio and this appears to be partially supported by previous research given that females are known to exhibit lower sympathetic activity (Ramaekers, Ector, Aubert, Rubens, & Van de Werf, 1998), as measured by low-frequency power. This difference in low-frequency power (female average low-frequency normalised power during the lower intensity conditions was 10.13 ± 1.62 whereas male low frequency normalised power was 10.82 ± 1.55) led to a difference in ratio between males and females during the 10% below ventilatory threshold conditions. The results appear to indicate that this gender difference is nullified during high-intensity exercise given that there was no difference in HRV ratio during the 5% above ventilatory threshold conditions.

A finding that only emerged through the HRV data was that HRV low frequency and ratio were significantly different in the video-only condition compared to the other conditions. Low-frequency activity is related to sympathetic responses and the increase in such activity appears to indicate that participants were working harder during the video-only condition despite the workload being standardised across conditions. Further, low frequency activity has previously been associated with negative emotions (see Appelhans & Luecken, 2006), and the HRV data begin to suggest that the video-only condition elicited such emotions. However, the HRV data seem somewhat anomalous given that the control condition did not follow a similar pattern compared to the music-only and music-and-video conditions. The increased low-frequency activity, along with the self-report psychological measures, suggests that the video-only condition is least beneficial compared to the other experimental conditions. Moreover, the HRV variability data viewed singularly suggest that the video-only condition was more stressful than the control condition.

5.4.1 Practical Implications

These results present exercise professionals, for the first time, with evidence-supported and easily implementable options for ameliorating the affective experiences of individuals who find themselves exercising above the ventilatory threshold. This level of exercise intensity is a common occurrence in field settings, particularly among individuals who are beginning to exercise after prolonged periods of sedentariness. The implications of this finding for public health are evidenced in the proliferating data on the role of during-exercise affect (Williams et al., 2012) and enjoyment (Rhodes et al., 2009) in promoting exercise behaviour. Music-alone and music-and-video interventions have the advantage of requiring no prior training before they can yield meaningful benefits. Exercise and health professionals have an emerging evidence base through which to tap the affective, dissociative, and motivational qualities of auditory and visual stimuli at exercise intensities that are associated with significant cardiorespiratory benefits.

5.4.2 Limitations of the Present Study

Despite efforts to create an immersive environment in the laboratory, it is not possible to replicate the sensations associated with a real-life parkland environment (with the breeze in one's face, the warmth of the sun, the sound of birdsong, etc). The efficacy of exercising outdoors versus indoors has been established in the literature (e.g., Hug et al., 2009), but it is not possible to delineate the efficacy of the visual or auditory outdoor environment independently and it is likely that exercising in an outdoor environment as a holistic experience is responsible for its efficacy; the removal of one or other stimulus potentially limits the appeal of outdoor exercise.

During the maximal testing and initial identification of ventilatory threshold, it became apparent that the time between ventilatory threshold and $VO_{2\ max}$ varied among participants. Therefore some participants may have been exercising closer to their $VO_{2\ max}$ than others. This inter-individual variation may have led some participants to exercise closer to their RCP (after which there is a universal drop in affect according to the dual-mode model; Ekkekakis, 2003) than others.

It was intended that attentional style (predominantly associative or dissociation) would be an independent variable in the present design owing to findings that suggest how this individual differences factor can influence responses to music during exercise (see Study 2). However, only seven of the 34 experimental participants could be classified as *Dissociators*, which would have limited any meaningful between-subject comparisons. Future studies might start with a far larger pool of participants in order to facilitate such comparisons.

The present sample comprised young adults aged 18-25 years who were moderately active and thus the findings cannot be generalised to the wider population without replication using a more representative demographic. Further, the sample was homogenous in terms of race (Caucasian) and socio-cultural background which limits generalisability owing to the differences in music preference between cultures (North & Hargreaves, 2008).

5.4.3 Future Directions

A direction that was alluded to in the present study involves the exploration of the degree of immersion that is required to optimise the effects of audio-visual stimuli on affect. For example, what types of video material are more effective? The present study used point-of-view parkland footage that was deemed pleasant, but the affective responses were less pleasant than the music only and music and video conditions. It may be that more engaging footage leads to a more potent affective response. Further, is there a difference between methods that vary in the extent of immersion (e.g., speakers versus headphones; screens, virtual reality goggles)? The extent to which the participants were immersed in music and video in the present study is not easily replicated in environments such as gymnasia, and an interesting extension would be to examine the influences of music and video such settings. The advancement of technology, such as virtual reality goggles, is leading to equipment becoming more affordable and these developments represent an opportunity for researchers to change the visual and audio environment in which people exercise. A potentially fruitful line of investigation would be to assess whether the creation of a fully immersive artificial environment can influence affect during exercise.

Future studies could examine a broader range of exercise intensities than the two examined in the present design. For example, a design similar to that employed in Study 1 wherein a range of exercise intensities from 40%–90% maxHRR were examined may be appropriate. Intensities across such a wide range would allow for a wider exploration of the potential influence that music and video interventions could have. The results from the present study suggested a *ceiling effect* regarding the amount of dissociative thoughts during exercise. An examination of interventions across a range of exercise intensities may provide insight into the maximum levels of dissociation that are possible during exercise.

The dual-mode model indicates that exercise at severe intensities will only result in decreases in affect with no scope for variability. The marker of severe exercise is the RCP and individuals would need to be tested beyond this point in order to examine whether the music-only and music-and-video conditions can enhance affective valence during severe intensities. This presents both theoretical and practical issues: The dual-mode model indicates that during severe exercise the interoceptive cues bypass the somatosensory and prefrontal cortex and signals take a "low road" directly to the amgydala indicating that environmental stimuli during severe exercise cannot influence affective responses as the interoceptive signals are not cognitively processed. Practical issues pertain to an inability to maintain exercise above RCP for a sufficient enough duration to practicably implement the aforementioned interventions. The amount of time that an individual can sustain exercise at this intensity is strongly determined by training status and mental toughness. An examination of responses at such exercise intensities offers an interesting test of theory, but has limited practical application owing the potential negative health effects of exercising at such intensities.

From a theoretical standpoint, future studies could combine audio-visual stimulation with an exploration of brain activity via the use of other non-invasive methods, such as near-infrared spectroscopy (Ekkekakis, 2009). The present study sought to use HRV as an exploratory non-invasive measure of brain function and it is imperative that future research seeks to examine responses to stimuli using both subjective and objective measures. A further research avenue would be to examine the theoretical posits of dual-mode theory using a design similar to that of the present study, however, participants would be required to exercise at severe exercise intensities (at RCP). The dual-mode model posits a universal decrease in affect during exercise at this intensity and an interesting study would be to examine whether this decline in affective response could be arrested through interventions such as music and video.

Future research in this lineage must seek to examine participants from a wider age range and from broader socio-cultural backgrounds in order to explore whether the positive responses to music only and music and video conditions is consistent across different populations. If a study includes participants of an age range older than the present study, researchers should be mindful of differences in music preferences and that older participants will prefer slower music in an exercise context (see Priest et al., 2004).

5.5 Conclusions

The expected Condition x Intensity interaction across the span of dependent variables did not emerge, rather, a series of main effects for condition and intensity emerged. Collectively, the present findings point to the efficacy of asynchronous music in singularity and asynchronous music with video as an adjunct to exercise at both moderate and high intensities. The increase in dissociative thoughts during the music-and-video combined condition did not lead to concomitant increases in other psychological outcome measures (e.g., affective valence, flow); therefore it may be that using video footage of a pleasant parkland scene as an accompaniment to music represents a logistical barrier that may not be worth tackling in light of the negligible benefits compared to the use of music by itself. A surprising finding to emerge was that video-only did not differ from the control condition other than HRV HF/LF ratio wherein video-only appeared to elicit the most stress.

With regard to the dual-mode model (Ekkekakis, 2003), results supported the posit that affective response to exercise at intensities below ventilatory threshold are positive. However, these responses were more positive during the music-only and music-and-video conditions and enhance the affective response compared to a video-only and control condition. The findings also show that the music-only and music-and-video conditions led to a more positive affective response in the “zone of variability”; a finding of particular importance from both a theoretical and an applied perspective is that these manipulations maintained their effectiveness not only below the ventilatory threshold but also at an intensity 5% above it.

Chapter 6: General Discussion

The present research programme sought to extend previous work and make an original contribution to the music and exercise literature. This body of work is comprised of three studies that shared the overarching aim of furthering understanding of the application of music during exercise. This section includes summaries of the main findings for each of the three studies; a discussion regarding the commonalities throughout the studies, an appraisal of the general limitations that pertain to the research programme, implications for practice, and future research directions.

6.1 Overview of Main Findings

6.1.1 Study 1 (Chapter 3): On the stability and relevance of the exercise heart rate–music tempo preference relationship. This study sought to extend a series of studies exploring the relationship between exercise heart and preference for music tempo (Karageorghis et al., 2006a; Karageorghis et al., 2008; Karageorghis et al., 2011). The principal purpose was to assess the stability of a cubic relationship found in a previous study (Karageorghis et al., 2011). The second, and most novel purpose, was to examine a range of psychological outcomes with reference to this relationship. The findings from this study, the fourth in the series investigating the exercise heart rate-music tempo preference relationship, appear to indicate that the hypothesis of Iwanaga (1995a, 1995b) who predicted that the relationship would be linear in nature can be conclusively refuted.

Results indicated that the exercise heart rate-music tempo preference relationship is not stable across exercise modalities. The cubic relationship found with cycle ergometry (Karageorghis et al., 2011) was not evident in treadmill exercise. There was, however, some similarity between the range of tempi that are preferred across a range of exercise intensities (40–90% maxHRR), albeit the range for treadmill running (123–131 bpm) was narrower than for cycle ergometry (125–140 bpm). At the highest exercise intensity, very fast music elicited the most positive affective responses, whereas at low intensities, the medium tempo had a similar effect. With regard to attentional focus, there was a greater number of associative thoughts during the no-music condition when compared to the music conditions at all exercise intensities. Moreover, the point at which attentional focus switched from predominantly dissociative to predominantly associative occurred at an exercise intensity ~10% higher in the music conditions compared to control. Women appeared to derive greater benefit in terms of affective valence when compared to their male counterparts. Supplementary qualitative data indicated that the music conditions elicited a broad range of responses that were subsumed under the heading *enhanced exercise experience*.

6.1.2 Study 2 (Chapter 4): Psychological characteristics as predictors of psychological responses to exercise with music. A central aim of this study was to explore whether motivational orientation and dominant attentional style are relevant personal factors for affective, cognitive, and behavioural outcome measures in a music and exercise context. Results indicated that individuals with a dominant attentional style of dissociation (Dissociators) were less self-determined that those with a predominantly associative focus (Associators). Associators reported the most positive affective, cognitive, and behavioural outcomes. Individuals categorised as highly self-determined Associators reported the most positive responses with regards to affective, cognitive, and behavioural outcomes. The results from the structural equation model (SEM) indicated that almost 29% of the variance for affect could be explained by behavioural regulations for Dissociators, compared to only 4% for

Associators; a large difference in explained variance. The SEM also indicated that 25% of the variance for behavioural intent could be attributed to the behavioural regulations of Associators, compared to 18% for Dissociators.

6.1.3 Study 3 (Chapter 5): Psychological and psychophysiological effects of music and video during exercise. This study was based, in part, on the attentional focus findings from the first study in this research programme. The main purpose was to examine the effects of auditory and visual stimuli on subjective and objective measures during a stationary cycle task completed at exercise intensities above and below the ventilatory threshold. Results showed a series of main effects for condition and exercise intensity. There was only one interaction effect, Exercise Intensity x Sex, wherein males exhibited a sharp decline in LF/HF ratio from below to above VT exercise intensities.

Music-only and music-and-video conditions exhibited the highest scores for affective valence. Moreover, it appears that participants derived just as much benefit from music-and-video as they did from music-only conditions during high-intensity exercise. This pattern of findings was replicated for measures of flow and enjoyment. There was a significant main effect for condition with perceived activation, wherein the music-only and the music-and-video conditions elicited the highest levels; however, perceived activation did not differ by exercise intensity. State attention data indicated that the music-and-video condition resulted in the greatest number of dissociative thoughts; music-only and video-only did not differ from the control condition at either intensity. A significant main effect for HRV ratio data indicated a higher LF/HF ratio in the video-only condition compared to the other conditions, and this difference in ratio data could be attributed to a difference in low-frequency power.

6.2 Common Themes

There is a series of commonalities among the studies in the present research programme owing to similar measures being included in each study. All three studies included measures of attentional focus, affect, and flow. The links between the results of these measures across the studies are explored herein.

6.2.1 Attentional focus. Previous findings pertaining to the dissociative effects of music during exercise indicate that dissociation primarily occurs at low-to-moderate exercise intensities (e.g., Boutcher & Trenske, 1990; Szabo et al., 1999). However, direct measurement of attentional focus during an exercise-to-music task had not previously been conducted; attentional focus was often inferred through the diminishing effects of music on RPE (as per Rejeski's [1985] model). Study 1 and Study 3 included direct measures of attentional focus through a self-report measure (Tammen, 1996). The direct measurement of attentional focus in these studies represents a methodological advance in the music and exercise literature and the inclusion of this measure has shed light onto the dissociative effects of in-task music use. Specifically, Study 1 demonstrated that music conditions can delay the switch from predominantly dissociative focus to predominantly associative focus by ~10% maxHRR (see Figure 3.12). This novel finding gave some insight regarding the extent to which music can promote dissociation and provided direct empirical evidence to support previous work (e.g., Terry & Karageorghis, 2006). However, this finding was limited in scope owing to the method employed in determining exercise intensity. Study 3 sought to further investigate the possible delay in switching from a predominantly associative to a predominantly dissociative attentional focus as a result of listening to music by adopting a more sophisticated physiological approach.

The finding from Study 1, that attentional focus could be manipulated during moderate-to-high intensity exercise, was a significant driver for the methodological approach in Study 3. Study 3 examined the effects that attentional manipulations (music and video) have on the exercise experience above and below the key biological marker of ventilatory threshold (see Ekkekakis et al., 2011). The findings from Study 3 – that motivational music by itself, and when used in conjunction with point-of-view video footage, can influence affective variables both below and above ventilatory threshold – represent a novel contribution to the music and exercise literature. Although the effects of the interventions were less potent during the higher exercise intensity, the pattern of results remained the same. The efficacy of the music-only and music-and-video conditions compared to the visually and auditory sterile control conditions was evident at both exercise intensities.

The reliability of the finding that interventions including music can shift the transition from dissociative to associative focus during high-intensity exercise is hinted at with the results from Studies 1 and 3. The ACSM (2006) have stated that percentage of $VO_{2\ max}$ and percentage of maxHRR are broadly regarded as equivalent measures of work intensity. If the exercise intensities employed in Study 1 are converted to percentage of $VO_{2\ max}$, the results of Study 1 and Study 3 can be compared along with data reported by Hutchinson and Tenenbaum (2007). As described in Study 1, Hutchinson and Tenenbaum employed a design wherein they measured participants' attentional focus (association/dissociation) across a range of exercise intensities. The results from this study directly informed the attentional focus hypothesis in Study 1 and can serve as a no-music comparator to the experimental and control conditions employed in Studies 1 and 3.

The lower exercise intensity in Study 3 equated to a workload of 50% $VO_{2\ max}$; this can be directly compared to the 50% $VO_{2\ max}$ condition employed in the Hutchinson and Tenenbaum (2007) study, and the 50% maxHRR conditions used in Study 1. The no-music condition at the lower exercise intensity in Study 3 led to the participants having a 60% dissociative focus; this compares with Study 1 where participants had a 64% dissociative focus; and Hutchinson and Tenenbaum where participants had a 78% dissociative focus. The results from Study 1 and Study 3 are remarkably similar, but there is some notable difference with the Hutchinson and Tenenbaum data. The issue highlighted by Masters and Ogles (1998) concerning the increased amount of association with verbal reports (as employed by Hutchinson & Tenenbaum) appears not to be supported. Masters and Ogles suggested that verbally reporting attentional focus would limit the scope for dissociation. However, the results presented here suggest that a verbal reporting technique increases levels of dissociation compared to a non-verbal method. A possible reason for this may be that participants are focused on reporting their thoughts, which requires processing capacity, and this occupies the attentional channel (Rejeski, 1985) which limits the processing of internal sensations. In essence, the task of reporting is a dissociative technique.

The music condition completed at the lower work intensity in Study 3 led participants to exhibit a 67% dissociative focus. This compares with Study 1 where participants had an 81% dissociative focus during the fast tempo music condition. Participants in the music-and-video condition in Study 3 reported a 73% dissociative focus. Interestingly, the amount of dissociative thoughts reported by Hutchinson and Tenenbaum (2007) is much closer to the music conditions (Study 1) and the music-and-video condition (Study 3) which supports the notion that verbal reporting could be a dissociative technique.

Following a similar approach, the higher exercise intensity in Study 3 equated to 64% $VO_{2\ max}$; this can be compared to the data from Hutchinson and Tenenbaum (2007), and data from Study 1 through plotting the data and interpolating the required exercise intensity. The no-music condition in Study 3 led participants to report a 35% dissociative focus, compared to Study 1 where participants reported a 55% dissociative focus, and data from Hutchinson and Tenenbaum's study indicated that 49% of thoughts were dissociative. The difference between the results presented in Studies 1, 3, and by Hutchinson and Tenenbaum is less than during the lower exercise intensity condition. This offers support for the earlier suggestion that verbal reporting of attentional focus is a dissociation technique. Tenenbaum's model (2001) suggests that as exercise intensity increases there is less scope to switch between a dissociative and associative focus. The reduction in difference in dissociative focus across Studies 1, 3, and Hutchinson and Tenenbaum offers some support for the diminishing ability to dissociative as exercise intensity increases. The music condition completed at the higher exercise intensity in Study 3 led participants to report a 40% dissociative focus; this compares to Study 1 where participants reported a 68% dissociative focus. Participants in the music-and-video condition in Study 3 reported a 47% dissociative focus.

The results from Study 1 and Study 3 indicated a significant main effect ($p < .05$) for state attention. These results only partially support the models of Rejeski (1985) and Tenenbaum (2001). The overall pattern of results indicates greater capacity to switch between association and dissociation at lower exercise intensities, but the results offer some evidence that attention can be manipulated to a more dissociative focus at high exercise intensities.

Some of the results from Study 1 and Study 3 described here are very similar (e.g., no-music condition at 50% exercise intensity), whereas others (e.g., music condition at 50% exercise intensity) appear to be somewhat different despite the stimulus being similar (in regard to tempo and motivational quotient). This presents a mixed picture in terms of the reliability of the direct measure of attention that was employed in Studies 1 and 3. Although care should be taken with the interpretation of such data owing to the differences in exercise modalities (cycle ergometry in Study 3 and Hutchinson et al., 2011, and treadmill exercise in Study 1), overall the findings presented in Study 1 and 3 demonstrate some consistency in the influence that interventions including music can have on attentional focus across different exercise intensities.

6.2.2 Affect. A central theme in all studies was the measurement of affective responses. Study 1 and 3 employed the Feeling Scale (Hardy & Rejeski, 1989), and Study 2 employed the Affect Grid (Russell et al., 1989). Results from Study 1 and 3 demonstrated that all music conditions (regardless of tempo) enhanced affective valence compared to no-music at all exercise intensities examined. The finding that asynchronous music conditions enhance affect compared to no-music during submaximal exercise offers support to previous work (e.g., Elliott et al., 2004; Elliott et al., 2005; Elliott, 2007; Shaulov & Lufi, 2009). A notable contribution of this research programme is the finding that declines in pleasure can be tempered by appropriate music selection, and in combination with video footage, even at exercise intensities above ventilatory threshold (see Ekkekakis, 2003). Previous work (e.g., Hutchinson et al., 2011) has found that asynchronous music can enhance the affective responses of participants during supramaximal exercise (i.e., Wingate protocol), however, the present research programme has made an original contribution to the understanding of how to enhance positive affect during high-intensity exercise of a longer duration.

Study 2 examined affective responses using an alternative methodological approach to that employed in Studies 1 and 3. The responses to an exercise-to-music session fell in the upper-right quadrant of the circumplex model (pleasant high activation; Russell, 1980), as measured by the Affect Grid (Russell et al., 1989), regardless of motivational orientation or attentional style. However, the level of pleasure was influenced by these two personal characteristics. The upper-right quadrant reflects pleasant high activation in the original circumplex model (Russell), and applications to music have shown this quadrant to reflect exciting music (North & Hargreaves, 1997). Overall, all three studies in the research programme provide further evidence that music possesses affect-enhancing qualities that can be employed during exercise to help positively shape the exercise experience across a wide range of exercise intensities.

6.2.3 Flow. The concept of flow (Csikszentmihalyi, 1990) has previously been explored in music and exercise contexts (e.g., Pates et al., 2003; Karageorghis et al., 2008) and featured in Terry and Karageorghis's (2006) conceptual model as a potential benefit of music use. Study 1 and 3 found that flow state followed a similar pattern to that of affective valence, insomuch as that music conditions (and music-and-video conditions in Study 3) enhanced flow state compared to no-music control conditions. These findings support those of Karageorghis et al. wherein all music conditions enhanced flow state when compared to a no-music control.

Flow state is a consequence of several factors including intense and focused concentration on the task at hand; a loss of reflective self-consciousness; a sense of personal control, a perceived distortion of time; and an experience that the activity is intrinsically rewarding (Nakamura & Csikszentmihalyi, 2002). If the application of music during exercise enhances flow compared to no-music, it is logical to propose that music is addressing one or more of the components required to promote flow state. Study 2 presented some evidence of how flow might be achieved with regards to *concentration on the present moment*. Individuals who enjoyed the exercise-to-music session the most (as evidenced by the highest levels of affect) also recorded the highest level of *concentration on the task at hand* (a subscale of the S FSS-2 and the measure used to assess cognitive consequences). The causal link between *concentration on the task at hand* and affect was not established in Study 2, but it seems plausible that engagement with the affect-enhancing music led to greater concentration. Results from Studies 1 and 3 also showed that flow and affect scores followed similar patterns; affect and flow were elevated in music conditions compared to a no-music control. These findings could be seen as support for the notion that listening to affect-enhancing music during exercise facilitates greater concentration on the task at hand (a component of flow state).

Evidence that the music conditions in Study 1 led to a perceived distortion of time can be found in the qualitative data. Participant 25 described that during the no-music condition she was "kind of waiting for the time to finish". Nakamura & Csikszentmihalyi (2002) stated that the distortion of temporal experience was usually manifest by the sense that time passes more quickly. Study 1 also includes results that may offer some insight into how flow is enhanced by music during exercise, specifically pertaining to the factor *an experience that the activity is intrinsically* *rewarding*. The music conditions led to significantly higher levels of intrinsic motivation, as measured by the interest-enjoyment and pressure-tension subscales of the Intrinsic Motivation Inventory (Ryan, 1982), compared to the no-music conditions. Although the results from the three studies in this research programme hint at the mechanisms by which music enhances flow (concentration on the task at hand, distortion of temporal experience, and an experience that the activity is intrinsically rewarding), these mechanisms warrant more detailed examination in the future.

6.2.4 Personal factors. Personal factors are an integral part of the conceptual frameworks for the application of music in sport and exercise (Karageorghis et al., 1999; Terry & Karageorghis, 2006). Compared to the number of studies examining the influence of musical components, there have been relatively few studies examining the influence of personal factors on the effects of music in an exercise context. Study 2 presented the first design to examine the associations between motivational orientation and dominant attentional style and affective, cognitive, and behavioural outcomes in a music and exercise context. The results demonstrated that a more self-determined approach to exercise is positively correlated with higher scores on affective, cognitive, and behavioural intent measures. Conversely, low self-determination is negatively correlated with affective, cognitive, and behavioural outcomes. These findings are in accord with the tenets of Self-determination Theory (Deci & Ryan, 1985). The differences in the outcome measures between attentional styles (Associators/Dissociators) also indicate that this personal factor may influence the intensity at which an individual experiences the outcomes. Previous research that embraced dominant attentional style (e.g., Brewer et al., 1996; Connolly & Janelle, 2003) has focused on ergogenic rather than psychological outcomes. The findings of

Brewer et al. and Connolly and Janelle indicate that an associative style is related to better task performance compared to a dissociative style. The results from Study 2 indicate a similar pattern but with the benefits of an associative style being related to psychological outcomes rather than ergogenic effects.

The instability of the exercise heart rate-music tempo preference relationship is likely due to a range of factors. A lack of understanding of personal factors was proposed to be one of a number of possible reasons for the instability of the relationship in Study 1. Karageorghis and Priest (2012b) suggested that “personal variables in musical reactivity within the exercise context are currently an underexplored area” (p. 76), and it appears that motivational orientation and dominant attentional style can influence responses to music. An original contribution of Study 2 pertains to the increased understanding of how these personal factors can influence the associations between outcomes measures and the application of music in exercise. The findings that emanated from Study 2 were intended to be implemented in Study 3 by controlling for dominant attentional style, but there were insufficient sample sizes to enable meaningful statistical comparison.

6.3 Limitations of the Present Programme of Research

Ekkekakis (2013) described the phenomenon of mood-congruent memory, specifically that mood facilitates appraisal of situational events in a way that is consonant with one’s mood (p. 46). That is, if a person is in a positive mood, they are more likely to respond in a positive way and vice versa. Participants’ mood was not assessed in any of the present studies. In line with the phenomenon of mood-congruent memory, it is unknown whether an existing mood will have such a significant bearing on emotions as to diminish the power of music to evoke positive emotions.

The results from Studies 1 and 3 are generalisable to a relatively specific population; young (18-25 years) white males and females who had spent their formative years in the UK. This represents a limitation to the generalisability of the results, although such restrictions were required to ensure the high internal validity of the studies. Further, the results from Study 2 can be generalised to the female British population, but cannot be generalised to the male British population. The predominance of female attendees at the exercise-to-music classes sampled in Study 2 was similar to that reported in previous work (e.g., North & Hargreaves, 1996; Priest et al., 2004; Ransdell et al., 2004).

The majority of data presented in the studies herein relied on self-report measures (e.g., the Feeling Scale, Felt Arousal Scale, state attention item). There are inherent issues regarding self-report measures and principal to these is the participants understanding of the question. The studies were designed to minimise the possibility of participants not understanding what was being asked of them. Where possible, a habituation session was included in the design and all participants were afforded the opportunity to ask questions. Moreover, comprehensive instructions accompanied each measure in order to assist with the participants understanding. An awareness of the limitations occurring as a result of a reliance upon self-report measures is evident in the attempts to include objective measurements when possible (i.e., heart rate variability).

The behaviour of the researcher collecting the data was standardised as much as practicable (e.g., questions would be phrased the same each time they were posed) in order to minimise any possible experimenter effects. However, the behaviour of the researcher, including non-verbal cues, is acknowledged as a factor that may have influenced participants' responses.

6.4 Practical Implications

Study 1 presented work that extended a series of studies examining the relationship between exercise heart rate and preference for music tempo. The results served to highlight the instability of the exercise heart rate-music tempo preference relationship across exercise modalities (cycling and treadmill exercise). However, it did confirm the proposition from Karageorghis et al. (2011) that a narrow range of tempi is preferred across a wide range of exercise intensities. The range of preferred tempi is narrower for treadmill exercise (123–131 bpm) than for cycle ergometry (125–140 bpm). A further contribution to the literature pertaining to the relationship between exercise heart rate and music tempo preference was the relevance of the relationship to psychological outcomes. There appears to be only a weak association between the most preferred tempo and a range of psychological outcomes. Therefore, as long as a piece of music is perceived by an exerciser to be motivational, it is likely to have a positive influence on psychological outcomes. Practitioners should, however, avoid using slow selections (< 100 bpm) for high-intensity activity or very fast selections (> 140 bpm) for low-intensity activity.

Study 3 presents exercise professionals with evidence-based and easily implementable options for enhancing the exercise experience of individuals who exercise above the ventilatory threshold. This level of exercise intensity is commonly experienced, particularly when individuals begin to exercise after prolonged periods of sedentariness. The use of music by itself, and in combination with video footage, could be used with individuals initiating an exercise programme in order to enhance affective responses, which in turn are likely to positively influence adherence (e.g., Williams et al., 2008).

Not only can music be applied to enhance acute affective responses, it could also be used to develop self-determination in an exercise context. Individual differences in motivational orientation and dominant attentional style appear to influence the affective, cognitive, and behavioural responses to music during exercise. Practitioners should seek to involve participants in the selections of music used during an activity as a way to address the underlying needs of autonomy that is associated with developing self-determination. Participants can make suggestions as to which tracks they would like to listen to during their exercise-to-music class and the instructors can seek to incorporate these suggestions into future sessions.

A logical assertion is that not all training or exercise sessions should be accompanied by music as the effects of music, like many other environmental stimuli, are likely to diminish with repeated exposure (cf. Karageorghis et al., 2006a). Moreover, in many competitive sports, music is not permitted during competition (e.g., in track and field), and its role has more to do with pre-competition preparation (Terry & Karageorghis, 2011). Although more empirical evidence is required to support this recommendation, advising competitive athletes to complete two sessions with music to one without appears a reasonable start point (Terry & Karageorghis).

6.5 Future Directions

An ambition underlying this programme of research was to gain further understanding of how to maximise the effects of interventions during exercise, which can help to positively shape the exercise experience. The links between affective responses and exercise adherence are gradually becoming better understood (e.g., Williams et al., 2008), and interventions designed to improve the affective responses of individuals during exercise are of great significance. The focus on music and video in the present research programme has offered some insight into how external stimulus applied in-task can positively shape the exercise experience. The studies in this research programme have posed a number of questions which future research may seek to answer.

6.5.1 Possible neuropsychological approaches. LeDoux (1996) suggested that psychological research has provided valuable insights into emotions, but studies examining emotions as brain functions represent a potentially more powerful approach. Electroencephalography (EEG) has been used in studies examining affective responses during exercise. Davidson (1998, 2000a, 2000b) hypothesised that regional brain activity may account for individual differences in affective responses, and this was examined through the use of EEG. Davidson established the predictive qualities of frontal EEG asymmetry through studies examining affective responses to stimulus such as film clips.

Petruzzello and colleagues (e.g., Hall, Ekkekakis, Van Landuyt, & Petruzzello, 2000; Petruzzello, Hall, & Ekkekakis, 2001; Petruzzello, Ekkekakis, & Hall, 2006) examined the predictive qualities of frontal EEG asymmetry in an exercise context and found that exercise intensity influences the relationship between resting frontal asymmetry and affective responses to the task. Specifically, frontal EEG asymmetry does not appear to be an effective predictor of affective responses as relatively low exercise intensities (i.e., 55–60% $VO_{2\,max}$; Hall et al., 2000; Petruzzello & Tate, 1997), but is a more accurate predictor at higher exercise intensities (70–75% $VO_{2\,max}$; Petruzzello & Landers, 1994; Petruzzello et al., 2001). The use of EEG in music and exercise studies may serve to further understanding of brain functions that influence the responses to music during exercise. Moreover, studies exploring the moderating influence of music during exercise on the predictive qualities of frontal EEG asymmetry may provide insightful objective data on the underlying brain functions of affective responses.

Adopting a similar approach to studies exploring the relationship between frontal EEG asymmetry and affective responses during exercise, Ekkekakis (2009) investigated the use of near-infrared spectroscopy (NIRS) as a method to measure changes in the cerebral cortex during exercise. Ekkekakis suggested that oxygenation of the prefrontal cortex increases at mild-to-moderate exercise intensities and decreases during strenuous exercise (at intensities that may be proximal to the respiratory compensation point). Further, NIRS offers insights into the workings of the prefrontal cortex during exercise and the integration of theories such as the dual-mode model into future investigations when using NIRS creates possibilities for research on cognitive function and the cognitive control of affective responses to exercise (Ekkekakis). The distinct benefit of NIRS is the capacity for it to be used *during* exercise. Future studies exploring the effects of music during exercise should seek to include NIRS as it is likely to offer great insight into brain mechanisms underlying responses.

Scherer and Zentner (2001) described how evaluation of a stimulus may occur in a rudimentary fashion at lower levels of the central nervous system; this is particularly relevant to evolutionarily “prepared” stimuli. It was suggested by Ohman (1988) that a number of stimuli (e.g., spiders and snakes) are processed by the lower brain regions in an extremely short period of time, prior to cortical involvement; and it also appears that facial expression of fear may have the same effect (Dimberg, 1988). Jurgens (1988) suggested that humans may have a similar “prepared” response to alarm calls (e.g., primal screams), and it may be that musical stimuli that are similar to that of alarm calls may provoke a response prior to cortical involvement (Scherer & Zentner). This suggestion by Scherer and Zentner has relevance to the models of attention proposed by Rejeski (1985), Tenenbaum (2001), and Ekekekakis (2003) which state that external stimuli are not easily processed during high-intensity exercise owing to overwhelming internal sensations. However, it may be that music has unique properties that provoke a response that does not require higher-level processing. There may be an evolutionary response to certain musical stimuli that provokes a positive response that does not require cortical processing. Indeed, Charles Darwin recognised the peculiar role of music in our emotional lives (Juslin, 2009).

Scherer and Zentner (2001) proposed that acoustic qualities of high pitch, wide range, and strong energy may be appraised by evolutionary primitive but extremely powerful detection systems. It may be this system, and an avoidance of cortical processing, that can be utilised to maximise the effects of music during moderate-to-high intensity exercise. The present results demonstrate that music can influence responses at moderate-to-high intensities and there may have been qualities in this music that tapped this primitive evolutionary response. Some of the music used in the experimental trials may have been an appropriate stimulus to provoke this response and may account for the responses to music even during moderate-to-high intensity exercise. If this line of investigation is to be explored further, which seems warranted particularly during high-intensity exercise, it seems appropriate to examine the effects of acoustic stimuli that may provoke an evolutionary primitive response.

6.5.2 Measurement of pain. Leventhal and Everhart's (1979) model "Parallel processing of information, pain, and distress" (p. 275) was the basis of Rejeski's (1985) model, and subsequently Tenenbaum's (2001) model. Whereas

Leventhal and Everhart's model incorporated emotion and pain, the models of Rejeski and Tenenbaum principally focused on perceived exertion. These latter models have been cited in a large number of music and exercise studies (e.g., Elliott, 2007; Elliott et al., 2004; Karageorghis et al., 2011) and a common measure of the effects of music is perceived exertion (e.g., Boutcher & Trenske, 1990; Szmedra & Bacharach, 1998; Karageorghis et al., 2013). Findings pertaining to perceived exertion have furthered understanding of the benefits of music, specifically that music can lower levels of perceived exertion during low-to-moderate levels of exercise intensity but music does not influence perceived exertion during high-intensity exercise. However, the data for affective responses do not appear to mirror that of perceived exertion as music does seem to influence affective responses even during high-intensity exercise (e.g., Study 1, Study 3, Hutchinson et al., 2011). It may be that perceived exertion is not an appropriate measure for some music and exercise study designs.

The ergogenic effects of music are of greater relevance to certain populations (i.e., competitive athletes), than others (e.g., recreationally-active participants). Measures of perceived exertion allow for insight into how hard a person feels they are working during an exercise bout, and lower levels are associated with increased work output (e.g., Hutchinson et al., 2011), but perhaps this measure is not always relevant in examining the exercise experience. It is proposed that perceived exertion is not an entirely relevant measure for a recreationally active, or physically inactive, population, while pain may be a more relevant index. Measures of perceived exertion are an indicator of physical strain (Borg, 1982), but they offer no acknowledgement of pain thresholds. Pain, or fear of pain, has been found to be a predictor of physical inactivity (e.g., Crombez, Vlaeyen, Heuts, Lysens, 1999; Ellingson, Colbert, &

Cook, 2012) and studies demonstrating the efficacy of interventions that reduce pain, or fear of pain, may be significant in the battle against physical inactivity. A common theme in the present research programme has been the dissociative effects of music. Dissociation is characterised by the blocking out of pain or discomfort (Lind et al., 2009), therefore it seems appropriate to measure pain during the application of music with exercise and this may offer greater insight into the effects and benefits of music rather than perceived exertion, particularly with a recreationally active or inactive population.

Measurement of pain typically uses one of four types of scales: pain threshold, pain tolerance, ratings of muscle pain, and multidimensional pain measures (Acevedo & Ekkekakis, 2006). Pain ratings can be recorded for sensory and affective dimensions of pain with muscle pain rating shown to be a valid and reliable measure (e.g., Cook, O'Connor, Eubanks, Smith, & Lee, 1997; O'Connor & Cook, 2001), and could be a useful tool for music and exercise practitioners. The pain-intensity scale employed by O'Connor and Cook was a 10-point category scale attached to a ratio scale. The pain-intensity scale is similar to Borg's CR10 RPE scale with 12 categories and verbal anchors accompanying numbers from 0-10 (e.g., 0 = no pain at all, 5 = strong pain). There is an unnumbered category that is signified by a dot and the verbal anchor of "unbearable pain".

Multidimensional pain measures may also provide greater insight into the effects of music during exercise, with separate assessments of sensory and emotional components of pain (e.g., Jenson, Karoly, & Braver, 1986). The use of two visual analogue scales to measure the intensity and emotional components of pain has been shown by Jenson et al. to be a straightforward and valid approach to the practical assessment of pain. The McGill Pain Questionnaire (MPQ; Melzack, 1975) is widely used to assess the multidimensional nature of pain. The MPQ assesses the sensory, affective, and overall pain experience and offers a viable method with which to further understand the role of music during exercise.

Study 3 sought to examine a psychophysiological outcome measure (Heart Rate Variability) as a method of objective measurement alongside the self-report subjective measures. This approach could be extended within the examination of pain through assessment of hormones related to pain. Although the chemical response to a pain stimulus is complex (see Chapman, Tuckett, & Woo Song, 2008), cortisol is a known marker of stress (see Dickerson & Kemeny, 2004). Further, other chemicals (e.g., endorphins, serotonin, and dopamine) may provide further insight into the biological mechanisms underlying responses to music during exercise. This approach would represent a new avenue of investigation for music and exercise researchers.

6.5.3 Attention. The measure of dominant attentional style used in the present research programme (AFQ; Brewer et al., 1996) has been used in a number of other studies (e.g., Connolly & Janelle, 2003; Masters & Ogles, 1998), but its relationship with in-task measures of attentional focus is unknown. An exploration of the association between the AFQ and in-task attention would shed more light on the relationship between dominant attentional style and attentional focus in-task. Taking the measures used in the present research programme, it is currently unknown how the AFQ and Tammen's (1996) state attention measure are related. Results from Study 2 demonstrated that a dominant associative or dissociative style can influence the exercise experience, but this was not accounted for in Study 3. It was originally intended that AFQ scores would be factored into the analysis but an insufficient number of Dissociators meant that statistical comparison would have been meaningless.

The finding that Associators experienced a more positive exercise experience than Dissociators was an unexpected finding. A line of discussion emerged relating to the measurement of association as a solely physiological index (e.g., Tammen, 1996). The concept of rumination may offer some further insight into the mechanisms underlying the positive benefits that Associators gained from the exercise-to-music sessions. Martin and Tesser (1996) described rumination in a social cognitive context (as opposed to rumination in a clinical context; Nolen-Hoeksema, 1991) as recurrent instrumental thinking about an unresolved goal, which is triggered by a perceived discrepancy between the current state and the desired goal and focuses on the perceived discrepancy until the unresolved goal is achieved or abandoned. Watkins (2009) suggested that within Martin and Tesser’s description, rumination has the potential to be constructive or unconstructive depending on whether the focus is on resolving the discrepancy through action (constructive) or not focusing (passive) on how to reduce the perceived discrepancy. This may offer further reason as to why an exercise-to-music session leads to more intense benefits for Associators as they feel as if they are actively pursuing a goal, therefore the session is more constructive for them.

If a person focuses inwardly on their emotions (ruminating), the response is an exacerbation of the emotion they are focusing on. Specifically, if a person ruminates on a positive emotion (happiness) then this emotion will be exacerbated, but this is equally true for negative emotions (Watkins, 2009). However, in an exercise-to-music context where the stimuli are known to enhance positive emotions, it could be postulated that an inward focus on these positive emotions will lead to *more* positive emotions (i.e., a more intense experience as was found in Study 2). Given the omission of internal focus on emotions in the current association/dissociation literature, as exemplified by the measures designed by Tammen (1996), and Stevinson and Biddle (1998), it might be appropriate to design a measurement tool that seeks to incorporate an internal focus on emotions and not just physiological symptoms. The literature and measures used for conceptualisations of rumination may offer some insight into how this can be achieved (e.g., Ruminative Response Scale; RRS; Treynor, Gonzalez, & Nolen-Hoeksema, 2003).

The RRS (Treynor et al., 2003) is comprised of 22 items that pertain to thoughts during negative mood states (i.e., sadness and depression). Responses are given on a 4-point Likert-type scale anchored by *almost never* and *almost always* with the items orientated towards cognitions (e.g., think about how sad you feel). Although the RRS (Treynor et al.) is directed at negative moods, it is the self-focused attention aspect of rumination that might be used in the development of a new measure of association/dissociation. Future measures of association/dissociation could seek to include items that capture a self-focus on emotions; this may offer greater insight into the reasons that underlie the benefits of an associative focus found in Study 2.

6.5.4 Exploration of exercise location in the application of music. Exercise location has been shown to have a significant influence on affective responses to exercise (e.g., LaCaille et al., 2004). The video protocol employed in Study 3 was similar to that of Pretty et al.'s (2005) study wherein 100 participants walked on a treadmill while viewing different urban and rural scenes. Their finding that a pleasant rural scene led to the most positive outcomes was the basis with which to select the video stimulus used in Study 3. Pretty et al. employed the design to establish a proof of principle that views of nature can influence physiological responses (blood pressure) and self-report measures (Profile of Mood States; McNair et al., 1971; Rosenberg Self–Esteem Questionnaire; Rosenberg, 1989). Pretty and colleagues, amongst others, have since advanced the 2005 study with a number of studies (e.g., Pretty, Hine, & Peacock, 2006; Barton, Hine, & Pretty, 2009; Sandercock, Angus, & Barton, 2010) that have provided empirical support for the mental and physical benefits of outdoor, or *green exercise*. The proof of principle established in the 2005 study led the way to studies that compared the benefits of indoor and outdoor exercise. A similar approach could be adopted within music and exercise studies, and the proof of principle has been established in Study 3 through the positive responses evoked by the music-and-video conditions.

The video footage used in Study 3 was not effective when employed as a singular stimulus. A number of reasons were presented for this, one of which related to the lack of any audio stimulus with the video footage which may have been an unusual experience for participants. A further suggestion related to the motivational (or lack of) qualities of the video footage. The footage was selected on the basis of "pleasantness" owing to a lack of guiding conceptual framework for motivational video footage used in exercise contexts. It seems appropriate to continue with exploring the influence that video footage can have, and footage that is congruent with the music (i.e., music videos) may lead to more positive results. An increased congruence between audio and visual stimulus may increase the level of immersion in the stimulus and in turn, offer a more effective distraction tool. A limitation noted in Study 3 was the lack of a conceptual framework to facilitate the selection of motivational video footage for exercise. Given the paucity of evidence supporting interventions to enhance in-task affect, the continued investigation into the effects of video footage could prove a fruitful endeavour. An initial point for any such research could be the conceptualisation of a framework for motivational video footage, a process that may follow a grounded-theory approach similar to that of Bishop et al. (2007) in their generation of a model for young tennis players' use of music to manipulate emotional state.

6.5.5 Generalisability of future studies. In line with previous suggestions (e.g., Crust, 2008; Priest et al., 2004) there is a need for more research to examine the influence of age in music and exercise settings. Previous research (Priest et al.) has offered initial insight into the different music preferences of age groups in an exercise setting, but no experimental studies have been conducted. The need for further studies examining the influence of age is exemplified by the limited generalisability of the exercise heart rate-music tempo preference relationship examined in Study 1. In addition to studies examining age, studies exploring the influence of components that constitute socio-cultural background (social class, area of residence, ethnicity, and peer group; Karageorghis & Terry, 1997) are needed to further understand the influence of these characteristics in an exercise context.

6.5.6 Development of conceptual frameworks. An issue that pervades the literature is the establishment of appropriate exercise intensities, particularly when considering posits of the dual-mode model wherein affective responses are a function of exercise intensity (Ekkekakis, 2003). Given the importance of exercise intensity on affective responses (see Ekkekakis et al., 2008), researchers should be mindful of the most appropriate techniques to set workload and the limitations associated with each method. If studies continue to employ specific exercise intensities and draw inference from these, the methodology behind the identification of workloads must be rigorous. This represents an opportunity for interdisciplinary studies between exercise psychologists and physiologists. The dualism that often permeates the affective literature (see Ekkekakis, 2009) represents a barrier to further progress and understanding. New conceptual frameworks that seek to incorporate exercise at their core, rather than borrowing elements from general psychology, are essential for the continued growth of this research area.

The conceptual models presented by Karageorghis et al. (1999) and Terry and Karageorghis (2006) have served to inform research over the past 14 years. However, the continuing research interest in the area has resulted in a much larger body of literature that now needs to be included in new conceptual frameworks. It is likely that future frameworks will be more expansive in scope and should seek to include the underlying mechanisms as well as the responses. A future model may take a similar antecedent, intermediaries, and consequences approach similar to that of Terry and Karageorghis' (2006). It is pertinent to note that, in a similar vein to the suggestion of North and Hargreaves (2008), it may not be appropriate for sport and exercise researchers to "re-invent the wheel" (p. 291) and to use advances in areas such as consumer psychology, environmental psychology, music psychology, cognitive psychology, public health to inform a future model.

6.6 Conclusions

The present programme of research explored underlying mechanisms which might account for the effects that in-task music can engender. Further, the research programme addressed how the effects of applying music during exercise might be maximised. The quadratic relationship between exercise heart rate and music tempo preference for treadmill exercise found in Study 1 led to the rejection of the hypothesis that the relationship would be cubic in nature and stable across exercise modalities. Although the relationship appears unstable, the results from Study 1 confirmed the narrow band of tempi that are most preferred across a wide range of exercise intensities (40–90% maxHRR). There is, however, only a weak association between optimal selection of music tempo and a range of psychological outcomes (e.g., affective valence). The implication of this is that to optimise such outcomes, a tempo range as broad as 100–140 bpm might be considered by exercise and health practitioners.

The focus of Study 2 was the underexplored area of the influence that personal factors can have in music and exercise contexts (Karageorghis & Priest, 2012b). The results indicate that motivational orientation and dominant attentional style are personal factors that should be considered by researchers examining responses to music during exercise. Individuals with highly self-determined motivation for exercise experienced the most positive psychological outcome measures (affective, cognitive, and behavioural) following an exercise-to-music session. Similarly, Associators experienced the most positive psychological outcomes. Personal factors feature prominently in conceptual models that have guided music and exercise research over the past 15 years (Karageorghis et al., 1999; Terry & Karageorghis, 2006). The results of this study emphasise the necessity to formulate updated frameworks that incorporate the most recent research findings.

Extant theory indicates that external stimuli, such as music, have minimal capacity to positively shape the exercise experience during high-intensity sessions (see Rejeski, 1985; Tenenbaum, 2001). However, Study 3 presented evidence for the efficacy of asynchronous music on its own and asynchronous music with video as an adjunct to exercise at both moderate and high intensities. The responses to both these interventions were more positive and led to enhanced affective responses when compared to a video-only and a control condition. This finding is of particular importance from both a theoretical and an applied perspective as these manipulations maintained their effectiveness not only below the ventilatory threshold but also at an intensity 5% above the threshold.

An aim for this line of research is to provide evidence in support for the affect–adherence claim that is gaining prevalence in the literature (e.g., Ekkekakis et al., 2013; Parfitt & Hughes, 2009). A strong evidence base for interventions which can positively shape the exercise experience is of crucial importance in the battle against physical inactivity. If a powerful evidence base for in-task interventions can be formed, it would encourage greater advocacy of physical activity as a viable and enjoyable solution to the health issues associated with a sedentary lifestyle. Moreover, an impactful case that demonstrates strong associations between affective responses and exercise adherence would help in framing physical activity and exercise in a context of *enjoyment* rather than *health*.

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Appendices

Appendix A

Head of School of Sport & Education
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Dr Costas Karageorghis
Deputy Head (Research)
School of Sport and Education
Brunel University

4th July 2011

Dear Costas

RE32-09 – On the stability of the Exercise Heart Rate Music Tempo Preference Relationship

I am writing to confirm the Research Ethics Committee of the School of Sport and Education received your application to amend/extend the above mentioned research study. Your amendments have been independently reviewed to ensure they comply with the University Research Ethics requirements and guidelines.

The Chair, acting under delegated authority, is satisfied with the decision reached by the independent reviewers and is pleased to confirm there is no objection on ethical grounds to you amending your study as proposed.

Any further changes to the protocol contained within your application and any unforeseen ethical issues which arise during the conduct of your study must be notified to the Research Ethics Committee for further consideration.

On behalf of the Research Ethics Committee for the School of Sport and Education, I wish you every success with your revised study.

Yours sincerely

Dr Gary Armstrong
Chair of Research Ethics Committee
School Of Sport and Education

Appendix B

Informed consent sheet

Please complete the whole of this sheet:	Please tick the appropriate box YES	NO
Have you read the Volunteer Information Sheet?	☐	☐
Have you had an opportunity to ask questions and discuss this study with a research assistant?	☐	☐
Have you received satisfactory answers to all your questions?	☐	☐
Who have you spoken to? ______________________________		
Do you understand that you will not be referred to by name in any report concerning the study?	☐	☐
Do you understand that you are free to withdraw from the study:		
- at any time	☐	☐
- without having to give a reason for withdrawing?	☐	☐
- without affecting your future treatment?	☐	☐
Do you agree to take part in this study?	☐	☐

Signature of Research Participant:
Date:
Name in capitals:
<u>Witness statement</u>
I am satisfied that the above-named has given informed consent.
Witnessed by:
Date:
Name in capitals:

Appendix C

Research Into Preferred Music for Exercise (pg. 1)

NAME: ___________________________________ (please print in BLOCK CAPITALS)

AGE: _______ years **EMAIL:** ____________________________________

GENDER: Male Female (please circle)

ETHNIC BACKGROUND (Please specify): _____________________________________
[e.g. White UK/Irish, Afro-Caribbean, Indian, French, etc.]

For the purpose of this study please complete this form as accurately and honestly as possible.

Your name will not be associated in any way with the information collected about you or with the research findings from this study which examines musical preferences. The researchers will use a participant number rather than your name. The researchers will not share information about you unless required by law or unless you give written permission for them to do so.

Permission granted on this date to use and disclose your information remains in effect indefinitely. By signing this form you give permission for the use and disclosure of your information for purposes of this study at any time in the future.

REFUSAL TO SIGN CONSENT AND AUTHORISATION
You are not required to sign this Consent and Authorisation form and you may refuse to do so without affecting your right to any services you are receiving or may receive from Brunel University.

PARTICIPANT CERTIFICATION
I agree to take part in this study as a research participant and will be asked to provide details of five musical selections. By my signature I affirm that I am at least 18 years old and have received a copy of this Consent and Authorisation form.

Date: ____ / ____ / 2011

Participant's Signature: ______________________________________
On behalf of the researchers: __________________________________

Now please turn over to list five musical selections!

Research Into Preferred Music for Exercise (pg. 2)

What would your five preferred musical selections be for high intensity short duration (two minutes) exercise? At least two of the five tracks must be a rock selection. You may include only rock or pop selections. This excludes jazz, latin and classical music.

For the purposes of our study, rock is defined in a broad sense and encompasses all guitar and drum-based styles from indie to heavy metal, while pop encompasses dance, disco, funk, hip-hop, R'n'B, grime, soul and UK garage. Could you please place your five tracks in order of your **perceived speed** of each (speed meaning *tempo*) and order them from slowest to fastest.

Slowest track	1) Title:	Artist:
	2) Title:	Artist:
	3) Title:	Artist:
	4) Title:	Artist:
Fastest track	5) Title:	Artist:

Please feel free to make any additional comments here:

____
____
____
____
____
____
____
____

Thank you!

Appendix D

Name: Participant number:

1) You have been exercising on a treadmill at various intensities during the course of this study, with musical accompaniment; what did you think of the music that was played?

2) Did the music have any effects at all on how you were feeling?

3) Did the music have any effects at all on what you were thinking?

4) Did the music have any effects at all on what you did (i.e. how hard you tried or your technique)?

5) You exercised at different intensities during the course of the study, do you think that the music had the same effect on what you were doing at every intensity or not? (This will not be asked if the participant said the music had no effect)

6) You exercised at different intensities during the course of this study; do you think that the music had the same effect on how you were feeling at every intensity or not? (This will not be asked if the participant said the music had no effect)

7) Did you notice any changes in the music other than the fact you were listening to four different tracks and sometimes there was silence?

8) How did you feel during the silent conditions? How about in terms of what you were thinking? What you were doing?

9) Describe the music that is best for low/moderate/high-intensity treadmill exercise.

10) Finally, I will play you excerpts of the four tracks that you heard during the course of this study and would like you to verbally place them in order of how you perceive the tempo of each -- from slowest to fastest. I will provide you with the titles of the tracks if you need them.

Track order:
1.
2.
3.
4.

Appendix E

Head of School of Sport & Education
Professor Susan Capel

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Leighton Jones
PhD Student
School of Sport and Education
Brunel University

3rd August 2012

Dear Leighton

RE50-11 – Psychological Characteristics as Predictors of Psychological Responses to Exercise with Music.

I am writing to confirm the Research Ethics Committee of the School of Sport and Education received your application connected to the above mentioned research study. Your application has been independently reviewed to ensure it complies with the University/School Research Ethics requirements and guidelines.

The Chair, acting under delegated authority, is satisfied with the decision reached by the independent reviewers and is pleased to confirm there is no objection on ethical grounds to grant ethics approval to the proposed study.

Any changes to the protocol contained within your application and any unforeseen ethical issues which arise during the conduct of your study must be notified to the Research Ethics Committee.

On behalf of the Research Ethics Committee for the School of Sport and Education, I wish you every success with your study.

Yours sincerely

PP

Dr Gary Armstrong
Chair of Research Ethics Committee
School Of Sport and Education

Appendix F

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Mr Leighton Jones
PhD Student
School of Sport and Education
Brunel University

17th October 2012

Dear Leighton

RE53-11 – Psychological and Psychophysiological Effects of Music and Video during Exercise.

I am writing to confirm the Research Ethics Committee of the School of Sport and Education received your application connected to the above mentioned research study. Your application has been independently reviewed to ensure it complies with the University/School Research Ethics requirements and guidelines.

The Chair, acting under delegated authority, is satisfied with the decision reached by the independent reviewers and is pleased to confirm there is no objection on ethical grounds to grant ethics approval to the proposed study.

Any changes to the protocol contained within your application and any unforeseen ethical issues which arise during the conduct of your study must be notified to the Research Ethics Committee.

On behalf of the Research Ethics Committee for the School of Sport and Education, I wish you every success with your study.

Yours sincerely

Richard Godfrey

Dr Richard Godfrey
Chair of Research Ethics Committee
School Of Sport and Education