Psychophysical Effects of Music in Sport and Exercise: An Update on Theory, Research and Application

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Abstract

This paper provides a narrative review of recent theory, research and applications pertaining to the psychophysical effects of music in the sport and exercise domains. A conceptual framework is presented, which emphasises that the principal benefits of music – improved mood, arousal control, reduced perceived exertion, enhanced work output, improved skill acquisition, flow states, dissociation from feelings of pain and fatigue – are determined by the four factors of rhythm response, musicality, cultural impact, and extra-musical associations. A simple example involves the tendency for humans to respond to the rhythmical qualities of music by synchronising movement patterns to tempo. Synchronous music has been reliably shown to produce an ergogenic effect. Therefore, if athletes or exercisers work in time to music, they will likely work harder for longer. Responses to asynchronous, or background, music are less predictable and beneficial effects are less reliable, although considerable potential remains if certain principles are followed. An example is that fast, upbeat music produces a stimulative effect whereas slow, soft music produces a sedative effect. Several evidence-based examples are presented of how music has been used effectively in our work as applied practitioners with groups ranging from exercise participants to elite athletes.

Introduction

The beneficial effect of using music in sport and exercise contexts has a long history and a strong intuitive appeal. Music has the capacity to capture attention, lift spirits, generate emotion, change or regulate mood, evoke memories, increase work output, reduce inhibitions, and encourage rhythmic movement – all of which have potential applications in sport and exercise. Considerable effort by researchers has been directed at understanding these effects, although many early studies used poor methods and had no underlying theoretical framework; issues we have addressed in a previous review (Karageorghis & Terry, 1997). Since that review, much new research has been published. The purpose of the present paper is to update theoretical developments, to critically review recent research into the psychophysical and ergogenic effects of music, and to provide examples of evidence-based music interventions for practitioners.

Theoretical Developments

Our original conceptual framework for predicting psychophysical effects of music held that four factors – rhythm response, musicality, cultural impact, and association – contribute to the motivational qualities of a piece of music (Karageorghis, Terry, & Lane, 1999). Rhythm response relates to natural responses to musical rhythm, especially tempo (speed of music as measured in beats per minute [bpm]). Musicality refers to pitch-related elements such as harmony (how the notes are combined) and melody (the tune). Cultural impact is the pervasiveness of the music within society or a sub-cultural group. Association pertains to the extra-musical associations that music may evoke, such as the composition *Chariots of Fire* by Vangelis, with Olympic glory. The four factors were shown to be hierarchical, with rhythm response the most important and association the least important. One implication of the conceptual model is that music can influence exercise enjoyment and participant retention, and by extension, has the potential to contribute to improved public health.

We later focused the conceptual framework in a sport context (Karageorghis & Terry, 2001), postulating that the main benefits athletes might derive from listening to music would be (a) increased positive moods and reduced negative moods; (b) pre-event activation or relaxation; (c) dissociation from unpleasant feelings such as pain and fatigue; (d) reduced ratings of perceived exertion (RPE) especially during aerobic training; (e) extended work output through synchronization of music with movement; (f) enhanced acquisition of motor skills when rhythm or association is matched with required movement patterns; (g) increased likelihood of athletes achieving flow states; and (h) enhanced performance via the above mechanisms. As reviewed below, recent research has provided support for these proposed benefits (see Figure 1).

Practitioners in sport and exercise environments tend to select music in a rather arbitrary manner without full consideration of its motivational characteristics (Priest, Karageorghis, & Sharp, 2004), highlighting the need for a standardised, theory-based method of selecting music. To date, there have been two attempts at developing a scale to rate the motivational qualities of music, the Brunel

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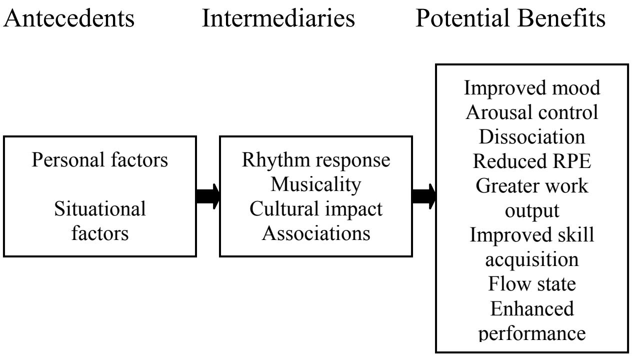

Figure 1: Conceptual framework for benefits of music in sport and exercise contexts.

Music Rating Inventory (BMRI; Karageorghis et al., 1999) and the BMRI-2 (Karageorghis, Priest, Terry, Chatzisarantis, & Lane, 2006). Karageorghis and colleagues proposed that the key characteristics of motivational music are that it has a fast tempo (>120 bpm), a strong rhythm, enhances energy, and promotes bodily movement. They also introduced the term *oudeterous* (from the Greek word meaning neutral) to denote music that is neither motivating nor demotivating.

Despite a good fit of the four-factor measurement model (rhythm response, musicality, cultural impact, and association), limitations were apparent with the original version of the BMRI. Some were reported in the validation article while others became apparent after its application in exercise, sport, and research contexts. Given the importance of measurement to the testing of theory, Karageorghis et al. (2006) radically redesigned the BMRI. This began with an extensive qualitative appraisal of the scale by exercise participants, results of which contributed to a new item pool. Each new item was structured to refer to an action, a time, a context and a target at the same level of generality (c.f., Azjen & Fishbein, 1977). The action concerned motivation, the time reference was *during* exercise; the context was exercise (although this could be changed to reflect alternative physical activity/sport settings); and the target was a property of the music such as rhythm or tempo. Hence, the generic form of each item was: "The *property* [e.g., melody] of this piece of music would motivate me during exercise".

The BMRI-2 focuses on the internal (music-related) factors of the conceptual framework rather than the external (person-related) factors. The qualitative analyses of Karageorghis et al. (2006) showed clearly that a psychometric measurement approach does not censor for the multitudinous facets of musical response. Some aspects of aesthetic experience transcend scientific investigation and it is important that we recognise the limitations of ardently applying a nomothetic approach to responses that may be highly idiosyncratic in nature. Nonetheless, the brevity (6 items) and simplicity of the BMRI-2 facilitate rating large pools of musical selections for further tests of theory and subgroup comparisons.

In very recent work, Bishop and Karageorghis (under review) applied a grounded theory approach to studying the antecedents, intermediaries, and consequences of music among 14 young tennis players. Results indicated four main benefits of music use: Improved mood, increased activation, visual and auditory imagery, and recall of associated films or music videos. The authors concluded that a grounded theory approach yielded a rich source of data and recommended its application to other sport contexts.

Recent Research Findings

Asynchronous Music

Most research has examined the impact of music as an adjunct to a physical task; where music is simply played in the background. Asynchronous use of music, as this is known, occurs when there is no *conscious* synchronisation between movement and music tempo. With asynchronous applications, tempo is postulated to be the most important determinant of response to music (Brown, 1979; Karageorghis et al., 1999) and preference for different tempi may be affected by the physiological arousal of the listener and the context in which the music is heard (North & Hargreaves, 1997). This suggests there might be a stronger preference for fast tempo music during physical activity, although some research has indicated that slower tempi may increase physiological efficiency and thus prolong exercise performance (e.g., Copeland & Franks, 1991). To address this issue, Karageorghis, Jones, and Low (2006) examined the relationship between exercise heart rate and preferred tempo. Participants reported their preference for slow, medium, and fast tempo music selections in each of three treadmill walking conditions at 40%, 60%, and 75% of maximal heart rate. A significant main effect for music tempo was found, whereby a general preference for fast and medium tempo music over slow music was evident ($\eta_p^2 = .78$). An intensity by tempo interaction effect was also observed ($\eta_p^2 = .09$), with participants reporting a preference for either fast or medium tempo music during low and moderate exercise intensities, but for fast tempo music during high intensity exercise.

Szabo, Small, and Leigh (1999) found that switching from slow to fast tempo music produced an ergogenic effect during cycle ergometry. The implication of this finding is that a change of music tempo from slow to fast may enhance participants' motivation and work output, especially when work level plateaus or in the latter stages of an exercise bout. Similarly, Atkinson, Wilson, and Eubank (2004) indicated that the careful application of asynchronous music during a simulated 10 km cycle time-trial could be used to regulate work output. The music was particularly effective in the early stages of the trial when perceived exertion was relatively low. Utilising the BMRI to rate the accompanying music, results supported the prediction that the rhythmical components of music contribute more to its motivational qualities than melodic or harmonic components.

Karageorghis and Terry (1999) assessed affective and psychophysical responses to motivational and oudeterous music during submaximal treadmill running at 50% VO_2

max using RPE, affect, heart rate, and post-exercise mood as dependent measures. They found affect differences between all conditions in the predicted direction and differences between the motivational music and control for the vigour component of mood and RPE. The results indicated that asynchronous music was more effective in influencing *how* participants felt (affect) rather than *what* they felt (exertion). This conclusion was corroborated in a subsequent study (Tenenbaum et al., 2004) using a hill running task at 90% VO_2 max which showed that although motivational asynchronous music did not influence perceptions of effort, it did shape participants' interpretations of fatigue symptoms. Considerable research has confirmed the effectiveness of background music as a strategy for mood enhancement (e.g., Hewston, Lane, Karageorghis, & Nevill, 2005; Terry, Dinsdale, Karageorghis, & Lane, in press).

Research has not always supported the benefits of motivational music. For example, Elliott, Carr, and Savage (2004) showed that, compared to a control condition, motivational music increased arousal and enhanced affect during submaximal cycle ergometry, but showed no benefits over oudeterous music; and neither music condition influenced the distance cycled. However, the motivational music tracks scored relatively low on the BMRI (M = 20.93; BMRI max score = 33.33), which may explain the lack of support for theoretical propositions.

In an investigation of the physiological processes underlying the benefits of music, Szmedra and Bacharach (1998) showed that background music was associated with reduced heart rate, systolic blood pressure, exercise lactate, norepinephrine production, and RPE during treadmill running at 70% VO_2 max. They suggested that music allowed participants to relax, reducing muscle tension, and thereby increasing blood flow and lactate clearance while decreasing lactate production in working muscle. However, it is notable that the beneficial effects of asynchronous music seem to disappear once exercise intensity reaches close to maximum. For example, a study of performance on the Wingate anaerobic test (a maximal effort over 30s) showed no benefit of music (Pujol & Lengenfeld, 1999). It appears likely that the intensity of physiological feedback would overwhelm the effects of music at maximal and supramaximal intensities.

Although this review has been eclectic rather than exhaustive, emergent trends are: (a) slow asynchronous music is inappropriate for exercise or training contexts unless used with the intention to limit effort exertion; (b) fast tempo asynchronous music played for high intensity activity yields high preference scores and is likely to enhance in-task affect; (c) an increase in tempo from slow to fast might engender an ergogenic effect in aerobic endurance activities; (d) asynchronous music played during submaximal exercise reduces RPE but it remains unclear whether this effect is moderated by the motivational qualities of music; (e) the most sensitive marker of the psychophysical impact of asynchronous music appears to be in-task affect, and (f) asynchronous music probably loses its benefits during very high intensity activities.

Synchronous Music

The synchronous use of music involves performing repetitive movements in time with its rhythmical elements such as the beat or tempo. One of the clearest examples of the benefits of synchronous music in sport was observed when Ethiopian athlete, Haile Gebreselassie, broke the indoor 2000-metre record in 1998 while synchronizing his stride rate to the rhythmical pop song *Scatman*.

Hayakawa, Miki, Takada, and Tanaka (2000) tested the effects of music on mood during step-aerobics classes using synchronous, asynchronous, and control conditions. Participants reported more positive moods when classes were conducted to synchronous music, although it was unclear whether effects were associated with the music or the physiological demands of the class (e.g., thermoregulation, oxygen uptake).

Research has consistently demonstrated the efficacy of synchronous music as an ergogenic aid in aerobic activities such as cycle ergometry (e.g., Anshel & Marisi, 1978; Karageorghis & Jones, 2000). Typically, synchronous music has been used to extend exercise duration among non-highly trained participants. Until very recently, however, there was no research into the effects of synchronous music on anaerobic endurance. Simpson and Karageorghis (in press) addressed this gap in the literature by testing the effects of synchronous music during 400m track running. Their results showed that both motivational and oudeterous music elicited faster times than no music (η_p^2 = .24), but times associated with the two music conditions did not differ; suggesting that the motivational qualities of music are not of critical importance when it is being used synchronously.

In sum, it appears that synchronous music can be applied to aerobic and anaerobic endurance performance among non-elite athletes and exercise participants with considerable effect. However, there is limited research and specific theory underlying the use of synchronous music, rendering this a particularly fruitful area for further investigation.

Pre-Task Music

A small body of research has investigated music as a pre-task stimulant or sedative. For example, Karageorghis, Drew, and Terry (1996) investigated effects of fast tempo, energizing music and slow tempo, relaxing music on grip strength. Participants produced significantly higher hand-grip dynamometer scores after listening to stimulative music compared to sedative music or a white noise control. Sedative music yielded lower scores than white noise. The authors concluded that a simple motoric task such as grip strength provides a sensitive measure of the psychophysical effects of music.

Karageorghis and Lee (2001) evaluated the effects of motivational music and imagery on isometric muscular endurance. They found that the combination of music and imagery, when compared to imagery only, enhanced muscular endurance performance, although it did not appear to enhance the potency of imagery. This was in contrast to previous findings (Gluch, 1993) and might be explained, in part, by the fact that an isometric muscular endurance task is highly motoric in nature, whereas imagery use has proven more effective in preparation for cognitive tasks (see White & Hardy, 1995).

Pates, Karageorghis, Fryer, and Maynard (2003) investigated the effects of pre-task music on flow states and shooting performance among three netball players. Two participants experienced increase perceptions of flow and all three improved their netball shooting performance. Participants also reported that the intervention had helped them to control the emotions and cognitions impacting upon their performance. The authors concluded that interventions including self-selected music and imagery could enhance athletic performance by triggering emotions and cognitions associated with flow. Similarly, Lanzillo, Burke, Joyner, and Hardy (2001) showed that self-selected music enhanced perceptions of state self-confidence. Collectively, research has shown that pre-task music can manipulate activation states through its arousal control qualities, facilitate task-relevant imagery, promote flow, and enhance perceptions of self-confidence.

Using Music in Sport and Exercise Contexts

Given that music preferences are a matter of personal choice, as practitioners, we are reluctant to provide play lists or dictate to athletes what music they should listen to. Nonetheless, adherence to a few simple guidelines can make it more likely that musical selections applied to individuals or groups will have the desired effect.

As a starting point, it is important to consider context. What type of activity are the athletes engaged in, and what is the desired purpose of the music? A particularly effective strategy is to get each member of the group to list their favourite music selections for different types of activity (e.g., travelling to competition, psyching-up, receiving physiotherapy, etc.) and to compile play lists based on tracks that are common to a number of group members. The BMRI-2 is useful in this regard as various activities can be substituted into the generic item structure in order to select music that is context-specific (e.g. "The rhythm of this music would motivate me during plyometric training"). It should be noted, however, that the BMRI-2 is not suitable for rating sedative qualities of music so there is scope for another music rating instrument to be developed.

Some activities lend themselves particularly well to musical accompaniment, particularly if they are repetitive and laborious in nature. Examples include warm-ups, weight/circuit training, stretching, etc. In each case, music of a rhythm and tempo to match the activity should be selected. For example, if the goal during warm-up is to elevate heart rate to 110 bpm, then limit choices to music with a tempo in the range 100-120 bpm or, better still, selections that increase gradually in tempo from resting heart rate (around 70 bpm) up to 120 bpm.

Evidence-Based Examples of Music Use

In working with the Great Britain bobsleigh squad at the 1998 Olympic Winter Games in Nagano, Japan, the first author impressed upon the four-man team that this was a rare opportunity – their moment in time – to clinch an Olympic medal. As the team drove to the bob track each day for training and competition, they would listen to Whitney Houston's *One Moment in Time* while visualising themselves calmly and decisively seizing the moment; which is precisely what happened on race day with a storming last run that clinched GB's first Olympic medal in the sport since 1964. Exactly the same strategy, indeed with the same song, was implemented successfully with gold medallist, double trap shooter Richard Faulds, at the Sydney 2000 Olympic Games.

Another Olympic champion, superheavyweight boxer Audley Harrison, studied sport psychology under both authors in the four years preceding the 2000 Olympics. He tapped the arousal control qualities of music through listening, perhaps counter-intuitively, to Japanese classical music prior to each bout. This served to temper his pre-fight anxiety, reduce tension, and create an inner state of calm and tranquillity.

The second author works with elite track and field athletes in the UK and has applied music interventions to athletes' training for many years. One such intervention entails first conducting a brief survey among the athletes to identify tracks they find most inspiring for training, which are mixed to punctuate circuit training so that work periods are accompanied by music and rest periods by silence. This approach to regulating the session reduces perception of effort while greatly enhancing in-task affect and enjoyment. A similar approach can be adopted for a range of exercise activities. The second author has also applied synchronous music to training in several motoric activities, including long-distance running, cycling, and rowing.

The use of synchronous music takes a great deal of preparation as the motor patterns of training activities and preferred motor rhythms of the athletes need to be studied carefully before selections are made. The music tempo is digitally altered to remain constant from track to track. Also, tempo is selected to coincide either with expected work rate, in which case the training activity is simply made more pleasurable, or to be marginally ahead of an athlete's preferred motor rhythm, in which case it stimulates athletes/exercisers to push their boundaries. Finally, the second author often uses music to improve young athletes' motor skills. One simple example uses the track *Push It* by Salt-n-Pepa to help athletes hone shot putt technique. The lyric reinforces the need for athletes to putt (i.e., push) the shot rather than trying to throw it, the most common technical error, which enhances the learning process.

These few examples of applying music with athletes and exercise participants highlight the importance for practitioners to be conversant with the potential benefits of music in order to tap its psychophysical and ergogenic properties with precision. It is also imperative that athletes or exercise participants are involved in the selection of tracks, as this is likely to increase the potency of music-related effects.

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