Sporting Sounds: Relationships between Sport and Music

By Bateman & Bale

The Psychological, Psychophysical, and Ergorenic Effects of Music in Sport: A Review and Synthesis

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> ‘In training build-ups for major races, I put together a playlist and listen to it during the run-in. It helps psych me up and remind me of times in the build-up when I’ve worked really hard, or felt good. With the right music, I do a much harder workout’.[1]
>
> **(Paula Radcliffe, Marathon world record holder)**

INTRODUCTION

Music has become almost omnipresent in sport and exercise environments. It blares out in gymnasiums, football stadiums and even in swimming pools through underwater speakers. Music is part-and-parcel of the modern-day sporting spectacle, while the advent of the *iPod* has better enabled athletes to cocoon themselves in their own auditory world. Does the use of music in sport actually yield higher performance levels or does it simply make sports participation and training more enjoyable? If music does indeed increase work output or enjoyment of a sporting activity, how can we go about maximising such benefits? These questions will be addressed within this chapter using the authors’ research findings and examples from their applied work with elite athletes.

Any musical composition requires the organisation of five primary elements: *melody*, *harmony*, *rhythm*, *tempo* and *dynamics*. Melody is the tune of a piece of music – the part you might hum or whistle along to; harmony acts to shape the mood of the music to make you feel happy, sad, soulful or romantic through hearing different notes at the same time (e.g. the strum of a guitar chord); rhythm involves the distribution of notes over time and the way in which they are accented; tempo is the speed at which music is played as often measured in beats per minute (bpm); whereas dynamics have to do with the energy transmitted by a musician through their touch or breath to impact on the loudness of their instrument. Rhythm and tempo are the elements of music most likely to prompt a physical reaction in the listener.[2] [3] Wilson and Davey noted that even when people sit motionless, ‘it is often very difficult to suppress the natural urge to tap the feet or strum the fingers along with the beat of the music.’[4]

In addition to a physical response, musical rhythm and tempo relate to the various periodicities of human functioning such as respiration, heart beat and walking.[5] Music and sport are purposefully intertwined at modern-day events with professional disc jockeys often hired to make appropriate selections to rouse the players or engage the crowd. Most teams have adopted their own anthems or signature tunes which increase team identity and the sense of cohesion. For example, at West Ham United F.C. the home fans sing the classic *I'm Forever Blowing Bubbles* while St Mary's Stadium at Southampton F.C. reverberates to the Dixieland favourite *When The Saints Go Marching In,* which was popularised by trumpeter Louis Armstrong in the 1930s.

Applied Example 1: Rugby music

It is ironic that many governing bodies of sport are currently considering banning, or have already banned the use of music in competition (e.g. the International Amateur Athletics Federation). As we write this chapter, UK Athletics is considering a recommendation by the UK Road Running Management Group to outlaw the use of personal music-playing devices at races. This is partly owing to the potential work-enhancing effects of music but also to the fact that music can be so intoxicating that it places athletes in mass-participation events in danger; they might knock into each other, miss instructions from officials or, in more extreme cases, risk getting hit by a car.

It was for these exact reasons that the organisers of the New York Marathon banned the use of personal music players in the 2007 event which prompted considerable media debate on the effects of music in sport, but also provoked widespread condemnation from competitors. Nonetheless, banning *iPods* and other mp3 devices in such large-scale events is almost impossible to enforce. Some race organisers, such as the International Management Group (UK) are organising half-marathon events with live bands lining the course. The music played is carefully selected to match the physiological demands of the event and the demographic profile of participants (see www.runtothebeat.co.uk).

HOW MUSIC AFFECTS THE HUMAN ORGANISM

In the domain of sport and exercise, researchers have primarily explored the *psychological*, *psychophysical* and *ergogenic* effects of music. *Psychological* effects refer to how music influences mood, emotion, affect (feelings of pleasure or displeasure), cognition (thought processes) and behaviour. The *psychophysical* effects of music refer to the psychological perception of physical effort as measured by ratings of perceived exertion (RPE).[6 7] In the music and sport literature, the term psychophysical is often used synonymously with the *psychophysiological* effects of music which relate to the impact of music on physiological functioning. In the interests of parsimony, we will use the term psychophysical with reference to the perception of physical effort and a range of physiological outcome variables (e.g. blood pressure, heart rate, ventilation, etc.). Music engenders an *ergogenic* effect when it enhances work output or yields higher than expected levels of endurance, power, productivity or strength. In this regard, music can be seen as a type of legal drug that athletes can use in training. Sydney Olympics rowing gold medalist, Tim Foster, now a respected coach, uses music to regulate all of the indoor workouts that he leads. He finds that this increases the motivation of his rowers as well as making the sessions far more enjoyable.

In a sporting context, music is used in three main ways. First, as *asynchronous* music whereby it is played in the background to make the environment more pleasurable and where there is no conscious synchronisation between movement patterns and musical tempo. Second, as *synchronous* music; this is typified by athletes using the rhythmic or temporal aspects of music as a type of metronome that regulates their movement patterns. Third, as *pre-task* music which entails using a musical stimulus to arouse, relax, or regulate the mood of an athlete or a team.

It is possible to use music in all three ways; for example, the Brazilian football team listens to stimulating latin American music in their dressing room while they mentally prepare (pre-task) and when they step onto the pitch, they are accompanied by a host of percussion musicians in the crowd. During play, the drums generally pound relentlessly in the background and thus exemplify the asynchronous use of music, however, on occasion, the team appear to lock into the lilting samba rhythm and it dictates the pace of play in a synchronous manner. No wonder then that the team is known as “The Samba Boys”.

MUSIC IN SPORT – AN OVERVIEW OF THEORETICAL DEVELOPMENTS

Until our review paper the approach taken to the study of music in sport or exercise was largely atheoretical in nature and unstructured.[8] We sought to provide researchers with a framework and methodological recommendations to guide their future scientific endeavours. In particular, we advocated greater rigour in the selection of music for experimental conditions with an emphasis on the age profile, preferences and socio-cultural background of experimental participants. We also provided recommendations on the design of music-related experiments with particular focus on the choice of appropriate dependent measures. Until the mid 1990s, the research in this area had yielded equivocal findings, making it difficult to gauge whether music had any meaningful effect when applied to sport-related tasks. Our review highlighted several methodological weaknesses that may have accounted for such varied findings and laid the foundations for the theoretical developments that followed.

The main weaknesses evident in past research were: (a) a failure to consider the socio-cultural background of experimental participants; (b) an imprecise approach to music selection or failure to report the music played; (c) inconsistencies regarding temporal factors such as the duration of music exposure and when it was played relative to the experimental task; (d) non-reporting of the intensity (volume) at which music was played and non-standardisation of this variable across tracks and experimental conditions; (e) inaccurate use of musical terminology by sports researchers; and (f) the use of performance measures that were either inappropriate or difficult to control.

In the decade since our review and accompanying methodological recommendations, there has been a significant improvement in the quality of published studies complemented by increased interest from sport and exercise researchers. Our 1997 paper covered the 25-year period since the review of Lucaccini and Kreit and critically appraised just 13 related studies.[9] In the subsequent decade, at least 43 related studies have been published. The present chapter will focus primarily on theoretical advances and research conducted in the period since our 1997 review.

OUR 1999 CONCEPTUAL MODEL

To address the paucity of relevant theory, we have published a number of conceptual frameworks over the past decade, two of which are reviewed here. Our original conceptual framework for predicting the psychophysical effects of asynchronous music in exercise and sport held that four factors contribute to the motivational qualities of a piece of music – rhythm response, musicality, cultural impact and association.[10] These factors were subject to empirical examination using both exploratory and confirmatory factor analyses.[11]

Rhythm response relates to natural responses to the rhythmical and temporal elements of music, especially tempo. Musicality refers to pitch-related (as opposed to rhythm-related) elements of music such as melody and harmony. Cultural impact draws upon the pervasiveness of music within society or a particular sub-cultural group, whereby frequent exposure to music increases its familiarity which has an important role in determining preference. Finally, association pertains to the extra-musical associations that music may evoke, such as Vangelis's composition *Chariots Of Fire* and its connection with Olympic glory. Such associations are built up by repetition and powerful images in which cinema, television, radio and the internet play a pivotal role.

When an association between a piece of music and a sporting activity is promoted by the media, this may elicit a conditioned response that can trigger a particular state of mind; for example, the Rocky theme *Gonna Fly Now* often evokes a state of optimism and excitement in the listener. Similarly, music can trigger a relaxation response to help ease an athlete's pre-competitive nerves. Its therapeutic, anxiety-relieving properties have been used through the ages. To illustrate how music can trigger a relaxation response, think of Lou Reed's classic track *Perfect Day* or go online to hear an excerpt on *YouTube* (www.youtube.com/watch?v=QYEC4TZsy-Y). The piece is so serene, so lyrical and so artfully structured that you will probably feel less tetchy and uptight, even by simply imagining the music in your mind.

Karageorghis, Terry and Lane indicated that the four factors have a hierarchical structure in terms of determining the overall motivational score or *quotient* of a given piece of music.[12] The two most important factors, rhythm response and musicality, are called *internal* factors because they relate to the structure of the music itself, and the other two factors, cultural impact and association, are called *external* factors because they relate to how the listener interprets the music. Motivational music is generally higher tempo (> 120 bpm), has catchy melodies, inspiring lyrics, an association with sporting endeavour and a bright, uplifting harmonic structure. Consider tracks such as *Put Your Hands Up For Detroit* by Fedde Le Grand or *I Feel Good* by James Brown, both of which typify motivational music in a sporting context. The relationship between internal and external factors, the motivational qualities of music and potential benefits can be seen in Figure 1.

Figure 1: Conceptual framework for the prediction of responses to motivational asynchronous music in exercise and sport. (Adapted with permission from Taylor and Francis; Journal of Sports Sciences, 17, 713-724)

The main benefits of listening to asynchronous music are that it can influence arousal or activation levels by acting like a stimulant or sedative. Research has shown that loud, upbeat music functions as a stimulant (increases arousal) while soft, slow music functions as a sedative (reduces arousal).[13 14] Music can reduce perceived exertion (RPE) although this effect is most pronounced during submaximal work intensities. During high intensity training activities, such as sprinting or weightlifting, physiological cues have the dominant influence on attention and, owing to an automatic switch from external cues to internal (bodily) cues, music has a negligible effect on perceived exertion.[15 16 17] Rejeski's parallel processing model is often mentioned with reference to the diminution of the effects of music as work intensity increases.[18] The aspect of the model most relevant to this phenomenon is known as the *load-dependent hypothesis*; when work intensity increases beyond anaerobic threshold, external cues such as music do not have any significant impact on perceived exertion.

Music can also enhance the positive aspects of mood such as vigour, excitement and happiness, and reduce the negative aspects such as boredom, tension, depression, anger, fatigue and confusion.[19 20 21] Collectively, such benefits can impact upon adherence to exercise or sports training by making such activities more pleasurable, or else be used as part of a pre-event routine to engender an optimal mindset (arousal control and improved mood).

In tandem with the development of our 1999 conceptual model, we developed an instrument to rate the motivational qualities of music: the Brunel Music Rating Inventory (BMRI).[22] Many subsequent studies have used the BMRI or its derivatives (e.g. the BMRI-2) to rate the motivational qualities of music used in experimental conditions objectively.[23 24 25 26 27 28] Such studies have demonstrated that if the age and socio-cultural background of participants is taken into account during the music selection process, and consideration is given to the congruence of music with the task, significant positive psychophysical and ergogenic effects are likely to ensue.

OUR 2006 CONCEPTUAL MODEL

In 2006, we developed a conceptual framework that was focused primarily in a sport context to reflect the growing list of potential benefits that were coming to light through empirical studies (see Figure 2).[29] The model identified the potential benefits of music use for athletes as being: (a) increased positive moods and reduced negative moods; (b) pre-event activation or relaxation; (c) dissociation from unpleasant bodily sensations such as pain and fatigue; (d) reduced RPE; (e) increased work output through synchronisation of movement with musical tempo; (f) enhanced acquisition of motor skills when rhythm or association matches required movement patterns; (g) increased likelihood of athletes experiencing flow; and (h) enhanced performance levels via combinations of the above mechanisms. The literature that is reviewed and synthesised herein provides considerable support for these proposed benefits.

Figure 2: Conceptual framework for the benefits of music in sport and exercise contexts. (Reproduced with permission from Australian Psychological Association; 2006, Proceedings of the Joint Conference of the Australian Psychological Society and the New Zealand Psychological Society, 415-419)

ASYNCHRONOUS MUSIC

Most commonly, researchers have investigated the psychological and psychophysical effects of asynchronous music rather than its ergogenic effects. Tempo is postulated to be the most important determinant of the response to music and preference for different tempi may be affected by the physiological arousal of the listener and the context in which the music is heard. [30 31 32 33 34] Accordingly, there should 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.[35]

Applied Example 2: Sonja the swimmer

A body of work has investigated the relationship between working heart rate, usually during a training-related activity, and preference for music tempo.[36 37] Such work stems from the recommendations of exercise practitioners indicating that music tempo should be matched closely to expected heart rate.[38] Also, work in the field of experimental aesthetics indicates that the *arousal potential* of stimuli determines preference.[39] Berlyne explained arousal potential in terms of the amount of activity that musical 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 preference decreases towards the extremes of arousal potential in a quadratic or inverted-U relationship.

Using experimental protocols that required participants to self-regulate a pure tone and subsequently a piece of music, Iwanaga predicted a positive and linear relationship between heart rate and music tempo preference.[40 41] However, these early findings were criticised by the psychomusicologist LeBlanc who argued that the methodologies used were unrepresentative of those employed in traditional music research and generally lacking in external validity.[42] Essentially, under normal circumstances, listeners are seldom able to self-regulate the tempo of a piece of music and most judgements of tempo preference are made after a piece has been heard. LeBlanc argued that in traditional music research it was evident that listeners preferred tempi slightly higher than their heart rate if at rest or while performing normal activity (i.e. not physical training).[43] LeBlanc also highlighted that younger listeners generally preferred higher tempi.[44 45] This notion was supported through subsequent work in an exercise context which showed large differences in tempo preference between young listeners (17-26 years) and older adults (> 45 years).[46]

It was evident that Iwanaga's findings could be validated by having the same participants select their preferred tempi for varying work intensities. If they preferred tempi close to their heart rates at a range of work intensities, it would lend support to Iwanaga's hypothesis concerning a positive, linear relationship.[47 48] Accordingly, the first author initiated two experiments that examined the relationship between heart rate and music tempo preference.[49 50]

Karageorghis, Jones and Low investigated the relationship between exercise heart rate and preferred tempo.[51] Participants reported their preference for slow (80 bpm), medium (120 bpm), and fast (140 bpm) tempo music selections while working at 40%, 60% and 75% of maximal heart rate reserve (maxHRR) on a treadmill. There was a significant effect for music tempo, wherein a strong preference for fast and medium tempo music over slow music was evident regardless of work intensity. An exercise intensity by tempo interaction effect was also observed, 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 (see Figure 3).

Figure 3: Significant two-way interaction for Exercise Intensity x Music Tempo. (Reproduced with permission from the American Alliance for Health, Physical Education, Recreation, and Dance; 2006, Research Quarterly for Exercise and Sport, 26, 240-250)

Karageorghis, Jones and Stuart extended this line of investigation so that participants listened to entire music programmes rather than just excerpts of music.[52] This study was predicated on a suggestion from the preceding study that although fast-tempo music was preferred at a high exercise intensity, continued exposure to such music during an exercise bout would result in negative psychological effects such as boredom and irritation.[53] Therefore, Karageorghis et al. tested medium tempi, fast tempi, mixed tempi (tracks arranged in the order medium-fast-fast-medium-fast-fast) conditions and a no-music control condition while participants worked at 70% maxHRR on a treadmill.[54]

Measures of music preference, intrinsic motivation and global flow were taken. It was hypothesised that the mixed-tempi condition would yield the most positive psychological effects owing to the interspersion of medium and fast tempi. However, the findings did not support this hypothesis (see Figure 4) as it was actually the medium-tempi condition that elicited the most positive psychological effects. The authors suggested that there may be a step change in preference between 70% and 75% maxHRR in which participants express greater preference for fast tempi music. This coincides with the point at which the body begins to rely more heavily upon anaerobic pathways for energy production and exercisers become more acutely aware of bodily cues associated with fatigue (cf. load-dependent hypothesis).[55]

Figure 4: Combined male and female mean scores for IMI subscales, global flow and preference ratings. (Reproduced with permission from Thieme Publishers; in press, International Journal of Sports Medicine)

The inconsistent findings derived from these two studies led us to seriously question the positive and linear relationship proposed by Iwanaga.[56 57] Indeed, the extant findings have led us to hypothesise that the relationship between exercise heart rate and music tempo preference will display a quartic trajectory (with three points of inflection; see Figure 5). Specifically, during the early stages of an exercise bout, the relationship is linear, whereas during the moderate-to-high exercise intensities both fast and medium tempo music is preferred. Beyond 70% maxHRR, fast tempi are preferred and the linearity of the relationship resumes. Once exercise intensity exceeds 80% maxHRR, there will be a ‘ceiling effect’ for tempo preference as there are relatively few tracks recorded at tempi > 150 bpm. Considering the importance of familiarity in determining music preference, such high tempi are unlikely to be preferred regardless of work intensity.[58] Moreover, given the salience of physiological cues in determining attentional focus, it is unlikely that music at any tempo can be selectively attended to at high work intensities.[59] [60]

Figure 5: Hypothesised quartic relationship between exercise heart rate and preferred music tempo

Many athletes and practitioners struggle to determine the precise tempo of any given piece of music. To assist readers wishing to select music with reference to its tempo, we have included a table below showing the tempi of a range of music selections that have proven popular in the sport and exercise domain. There is also an applied example which follows that demonstrates how you might construct a music programme to accompany a typical training session. Should you wish to find out the tempi of your favourite musical selections, you might try internet sites such as www.thebpmbook.com, www.ez-tracks.com, or in the case of dance and hip-hop selections, www.jamglue.com. There are also various software packages such as *Tangerine* (www.potionfactory.com), which can assess the tempo of each track on your PC and automatically add this detail to an *iTunes* library.

Table 1: Widely-used music selections in sport and exercise contexts

Applied Example 3: An example of how musical selections can be moulded around the components of a typical training session

Szabo, Small and Leigh found that a switch from slow to fast tempo music yielded an ergogenic effect during static cycling.[61] 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 reaches a plateau or during the latter stages of an exercise bout. Similarly, Atkinson et al. indicated that the careful application of asynchronous music during a simulated 10 km cycle time-trial could be used to regulate work output.[62] The music was particularly effective in the early stages of the trial when perceived exertion was relatively low. Participants used the BMRI to assess the motivational qualities of accompanying music and their ratings supported the prediction that rhythmical components of music contribute more to its motivational qualities than melodic or harmonic components.[63]

A follow-up study by Lim, Atkinson, Karageorghis and Eubank investigated the effects of an asynchronous music programme used in different half-segments of a 10 km cycle time-trial.[64] The music was played either for the first half (M1) or second half (M2) of the trial and the two experimental conditions were compared against a no-music control (C). It was expected that music would have a greater impact on power output when introduced during the latter half of the trial although the results did not support this hypothesis (see Figure 6). In actuality, condition M2 yielded the highest power in the early stages of the trial when no music was played. A plausible explanation for this anomaly is that foreknowledge of the introduction or removal of music may have affected participants' pacing strategy. Notwithstanding this possible confound, Lim et al.'s methodology is representative of a fruitful new avenue of research that reflects the way in which music is used strategically in sporting settings.[65]

Figure 6: Impact of asynchronous music in the first half (M1) and second half of a 1
stationary cycle time trial, and a no-music control (C)

Karageorghis and Terry assessed affective and psychophysical responses to motivatior d oudeterous music during treadmill running at 50% VO_2 max using RPE, affect, heart r d post-exercise mood as dependent measures.[66] Motivational music had the most positiv influence on affect, RPE and the vigour component of mood. Differences were found primarily between the motivational and control conditions with no differences betweer oudeterous (neutral music) and control conditions. In a similar study, Szmedra and Ba ch showed that asynchronous music was associated with reduced heart rate, systolic bloo pressure, exercise lactate, norepinephrine production and RPE during treadmill runnin 70% VO_2 max.[67] The reduction in RPE for music vs. the control condition was ~10%, a figure replicated in a subsequent study by Nethery.[68] Szmedra and Bacharach 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.[69]

Using a very novel approach, Crust and Clough tested the ergogenic effects of motivational music, drumbeat only, and no music on isometric muscular endurance (holding a weight at shoulder height for as long as possible).[70] The drumbeat used was the same as that used in the motivational track but without the remaining constituents of music (melody, harmony, lyrics). Participants endured for longer in the motivational music condition compared to the other two, which highlights the importance of all aspects of music structure in determining musical response. The researchers also administered Cattell's 16PF personality inventory to their participants and a small but statistically significant relationship between personality type and musical response was found. Specifically, the personality dimensions of liveliness and sensitivity were both positively associated with musical response.

It is evident that the beneficial effects of asynchronous music are diminished once exercise intensity approaches maximal levels. For example, a study of supramaximal performance using the Wingate test (an all-out cycle ergometer effort over 30 seconds) showed that music had no benefit on performance, supporting the load-dependent hypothesis.[71 72] This finding was corroborated in a subsequent study using a treadmill and outdoor running task at 90% VO_2 max, where the researchers demonstrated that while motivational asynchronous music did not influence perceptions of effort, it did shape interpretations of fatigue symptoms.[73]

Not all research has supported the benefits of motivational music. For example, Elliott et al. showed that, compared to a control condition, motivational music enhanced affect during submaximal cycle ergometry, but showed no benefits over oudeterous (neutral) music; and neither music condition impacted upon the distance cycled.[74] However, the authors acknowledged that the supposedly motivational music tracks had relatively low motivational quotients on the BMRI (*M* = 20.92 compared to BMRI maximum score of 33.33), which may well explain the lack of support for theoretical propositions.

There are a number of clear trends to emerge from the body of research that has investigated the use of asynchronous music. Firstly, slow asynchronous music (< 100 bpm) is generally inappropriate for exercise or training contexts unless used to limit effort exertion or as an accompaniment for warm-up/warm-down activities. Secondly, fast-tempo asynchronous music (> 140 bpm) played during high intensity activity results in high preference ratings and is likely to enhance in-task affect. Thirdly, an increase in tempo from slow to fast can elicit an ergogenic effect in aerobic endurance activities. Fourthly, asynchronous music played during submaximal exercise reduces RPE by ~10% although it remains unclear the degree to which this effect is mediated by the motivational qualities of music. Finally, asynchronous music has a negligible effect on psychological and psychophysical indices during very high intensity activities, which substantiates the load-dependent hypothesis.[75]

SYNCHRONOUS MUSIC

People have a strong tendency to respond to the rhythmical and temporal qualities of music. This tendency sometimes results in synchronisation between the tempo or speed of music and an athlete's movement patterns. A much-cited example concerns the celebrated Ethiopian distance runner Haile Gebrselassie who, in February 1998, smashed the indoor world record for 2000 metres while synchronising his stride rate to the rhythmical pop song *Scatman*, which was played over loudspeakers.

Synchronous music is closely associated with sports such as figure skating, rhythmic gymnastics and synchronised swimming. Researchers have explained the synchronisation between musical tempo and human movement in terms of the natural predisposition of humans to respond to the rhythmical and temporal qualities of music.[76 77] Ostensibly, musical rhythm can replicate natural movement-based rhythms. Despite the intuitive appeal of this notion, relatively few studies have investigated the impact of synchronous music.[78 79 80 81]

Researchers have consistently shown that synchronous music yields significant ergogenic effects in non highly-trained participants. Such effects have been demonstrated in bench stepping, cycle ergometry, callisthenic-type exercises, 400-metre running and in a multi-activity circuit task. [82 83 84 85 86] Independent of such research, there has been a wave of commercial activity focused on the development and promotion of walking programmes that use synchronous music either to enhance fitness (e.g. www.run2r.com) or as part of a cardiac rehabilitation programme (e.g. www.positiveworkouts.com).

A landmark study by Anshel and Marisi compared synchronous and asynchronous music using a cycle ergometer endurance task.[87] Synchronous music elicited longer endurance than either asynchronous music or a no-music control (Cohen's d = 0.6 for synchronous vs. control). However, the music was chosen somewhat arbitrarily from the 'popular rock' category without due consideration of the musical preferences and socio-cultural background of the participants, suggesting that the potential effect may have been even greater.[88]

Hayakawa et al. compared the effects of synchronous and asynchronous music on mood during step-aerobics classes of 30-minutes duration.[89] Aerobic dance music was used for the synchronous condition while, unusually, traditional Japanese folk music was used in the asynchronous condition. Participants reported more positive moods when classes were conducted with synchronous music compared to asynchronous music and a no-music control. However, it remains unclear whether the purported benefits of synchronous music were associated with the music itself or the physiological demands of the class (e.g. thermoregulation or oxygen uptake). Moreover, it is also not apparent to what extent the results can be attributed to the style of music used or its synchronicity with the bench-stepping exercise.

In addition to the benefits associated with asynchronous music detailed within the conceptual framework of Karageorghis et al., it has been proposed that the synchronous use of music results in a reduced metabolic cost of exercise by promoting greater neuromuscular or metabolic efficiency.[90 91] This proposition was the subject of a very recent study by Bacon, Myers and Karageorghis.[92] Participants performing a submaximal cycle ergometry task were able to maintain a constant exercise intensity (60% of their maximum heart rate) using 7.4% less oxygen when listening to a selection of synchronous music compared to music that was asynchronous (slightly slower than the movement tempo). This study also showed that there were no differences in heart rate and RPE measures between synchronous and asynchronous cycling conditions.

Until recently, there had been scant research into the effects of synchronous music on anaerobic endurance performance. Simpson and Karageorghis sought to address this gap in the literature by examining the effects of synchronous music during 400-metre track running using an externally valid, race-like protocol.[93] Their findings showed that both motivational and oudeterous (neutral) music conditions elicited faster times than a no-music control condition (see Figure 7) and that the times associated with the two experimental conditions did not differ. This latter finding indicates that the motivational qualities of music may not be of critical importance when it is used synchronously for an anaerobic endurance task; a notion that is entirely consistent with the load-dependent hypothesis.[94] Nonetheless, there is considerable scope for further investigation of the ergogenic effects of music in anaerobic and rhythmical sports (e.g. canoeing/kayaking, cycling and rowing).

Figure 7: Mean 400-metre times for synchronous motivational music, synchronous oudeterous music and a no-music control

Applied Example 4: Khalida and the musical pacing method

In summary, the limited evidence that is available suggests that synchronous music can be applied to aerobic and anaerobic endurance performance among non-elite athletes to produce positive psychological, psychophysical and ergogenic effects. Very recent findings have indicated that synchronous music applied to submaximal repetitive activity can result in a ~7% decrease in oxygen uptake.[95] However, there is insufficient research and specific theory underlying the use of synchronous music, especially among elite athletes, rendering this a particularly fruitful area for future research.

PRE-TASK MUSIC

A few studies have examined the use of music as a pre-task stimulant or sedative. Building upon an earlier study by Pearce, we tested the effects of fast tempo, energising music and slow tempo, relaxing music on grip strength.[96 97] 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. This study demonstrated the powerful effects of music on even the most basic of strength tasks and showed that simple motoric tasks such as grip strength provide an effective means by which to test the ergogenic properties of music.

Karageorghis and Lee tested the effects of pre-task motivational music and imagery on isometric muscular endurance by requiring participants to hold dumbbells weighing 15% of their body mass in a crucifix position until they reached voluntary exhaustion.[98] The combination of music and imagery significantly enhanced muscular endurance performance compared to imagery only. This finding contrasted with an earlier study conducted by Gluch, a discrepancy that might be explained by the highly motoric nature of the endurance task, especially considering that imagery has typically proven effective in relation to cognitive tasks.[99 100]

Using an idiographic, single-subject, multiple-baselines, across-subjects design, Pates, Karageorghis, Fryer and Maynard examined the effects of pre-task music on flow states and netball shooting performance using three collegiate players.[101] Two participants reported an increase in their perception of flow and all three showed considerable improvements in shooting performance. Participants also reported that the intervention enabled them to control the emotions and cognitions that impacted 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. One potential limitation of this study is that the mental rehearsal and recall of flow states, which constituted part of the intervention, may have elicited the improvements in performance, rather than the music itself.

Along similar lines, Lanzillo, Burke, Joyner and Hardy examined the impact of pre-event music on competition anxiety and self-confidence among intercollegiate athletes from a wide variety of sports.[102] One group of athletes listened to a 3-minute selection of their preferred music prior to competition while a control group had no music intervention. The experimental group reported higher state self-confidence than the control group although there were no differences found in competition anxiety.

Applied Example 5: Olympic double-trap shooting champion Richard Faulds

In summary, research has shown that pre-task music can be used to: (a) manipulate activation states through its arousal control qualities; (b) facilitate task-relevant imagery/mental rehearsal; (c) promote flow; and (d) enhance perceptions of self-confidence. There is limited research in this area, which indicates considerable scope for further examination of the role of music in eliciting optimal pre-performance states and priming athletes in order to facilitate peak performance (see also chapters by Bishop and Karageorghis, and Loizou and Karageorghis in this text).

Applied Example 6: Strange choices also work, but for strange reasons ….

SUMMARY

We have presented two complementary conceptual approaches underlying the study and application of music in sport and exercise contexts.[103 104] We have also established that music can be applied to sports training and competition in many different ways, and have provided initial evidence for a quartic relationship between exercise heart rate and music tempo preference. One of the main demonstrated benefits of music is that it enhances psychological state, which has implications for optimising pre-competition mental state and increasing the enjoyment of training activities. Used synchronously, music can boost work output and makes repetitive tasks such as cycling or running more energy efficient. When we embarked upon our programme of research almost two decades ago, our intention was to promote more judicious use of music. The evidence that we have accumulated coupled with the findings of many other researchers from around the world, should allow athletes and practitioners to tap the psychological, psychophysical and ergogenic effects of music with greater precision.

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