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Psychological, psychophysical, and ergogenic effects of music in swimming

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ABSTRACT

Objectives: Existing work using dry land exercise-related activities has shown that the careful application of music can lead to a range of benefits that include enhanced affect, lower perceived exertion, greater energy efficiency, and faster time trial performances. The purpose of this study was to assess the psychological, psychophysical, and ergogenic effects of asynchronous music in swimming using a mixed-methods approach.
Design: A mixed-model design was employed wherein there was a within-subjects factor (two experimental conditions and a control) and a between-subjects factor (gender). The experimental component of the study was supplemented by qualitative data that were analysed using inductive content analysis.
Methods: Twenty six participants (M_{age} = 20.0 years, age range: 18–23 years) underwent a period of habituation with Speedo Aquabeat MP3 players prior to the experimental phase. They were then administered two experimental trials (motivational and oudeterous music at 130 bpm) and a no-music control, during which they engaged in a 200-m freestyle swimming time trial.
Results: Participants swam significantly faster when exposed to either music condition relative to control (p = .022, η_p^2 = .18). Moreover, the music conditions were associated with higher state motivation (p = .016, η_p^2 = .15) and more dissociative thoughts (p = .014, η_p^2 = .16).
Conclusions: Findings supported the hypothesis that the use of asynchronous music during a high-intensity task can have an ergogenic effect; this was in the order of 2% when averaged out across the two experimental conditions. The use of music, regardless of its motivational qualities, resulted in higher self-reported motivation as well as more dissociative thoughts.

Music use is widespread in the sport and exercise domain and advances in underwater MP3 player technology have led to its burgeoning popularity in swimming and other water-based activities. A lineage of work has assessed the psychological, psychophysical, and ergogenic effects of music in a range of dry land activities that include 400-m running (Simpson & Karageorghis, 2006), cycle ergometry (Anshel & Marisi, 1978), indoor rowing (Rendi, Szabo, & Szabó, 2008), treadmill walking (Karageorghis et al., 2009), and long-distance running (Terry, Karageorghis, Mecozzi Saha, & D'Auria, 2012). Psychological effects relate to how music influences mood, affect, emotion, attitudes, cognition, and behaviour. Psychophysical effects concern the reduction of perceptions of physical effort, which, in the music-related literature, are most often assessed using ratings of perceived exertion (RPE). Ergogenic effects relate to the use of music to improve physical performance by either delaying fatigue or increasing work capacity; this results in higher-than-expected levels of endurance, power, productivity, or strength (see Terry & Karageorghis, 2011).

Extant work has shown that music use is not effective for some people under certain circumstances (e.g., while learning new skills) and might even be contraindicated in some instances (e.g., when it might distract users from safety-relevant information, such as on public roads; see Karageorghis & Priest, 2012a, 2012b for a review). Also, a "vitamin model" wherein a particular piece of music can be prescribed to engender certain perceptual, cognitive, or emotional responses in a listener, does not apply to this field of scientific endeavour (Sloboda, 2008). There are multiple considerations that researchers need to take into account when selecting music and these include socio-cultural, task-related, and personal factors (see e.g., Karageorghis & Terry, 1997; North & Hargreaves, 2008). Much of the preliminary work in this field was characterized by a lack of sensitivity to such factors; music was viewed in a manner akin to any other auditory stimulus wherein little consideration was given to its aesthetic qualities (e.g., Anshel & Marisi, 1978; Boutcher &

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Trenske, 1990). Unsurprisingly then, such early research yielded a string of equivocal results.

Early work was also characterized by an atheoretical approach which led Karageorghis and his associates to develop a conceptual framework and an assessment tool – the Brunel Music Rating Inventory – through which the motivational qualities of music could be standardized for experimental tasks (see Terry & Karageorghis, 2011 for a review). The scope of the first conceptual framework (Karageorghis, Terry, & Lane, 1999) was limited to the *asynchronous* application of music. This is relevant to the present study and concerns the use of music without a performer's conscious effort to synchronize their movements with the rhythms of that music. The framework encompassed four factors arranged in a hierarchical order that were thought to contribute to the motivational qualities of a piece of music: *rhythm response*, *musicality*, *cultural impact*, and *association*. Rhythm response and musicality denote auditory properties of music and were thus termed *internal factors*, whereas cultural impact and association pertain to social and cultural influences on our interpretation of music and were thus termed *external factors*.

The framework indicated that the main benefits associated with the asynchronous use of music were arousal regulation, reductions in RPE, and enhanced mood. It has received broad support in the literature (e.g., Atkinson, Wilson, & Eubank, 2004; Crust, 2008) and was modified by Terry and Karageorghis (2006) to include a range of additional benefits that came to light during the period from 1999 to 2006 (e.g., dissociation, flow experience, and enhanced work output). The 2006 framework also embraced the *synchronous* application of music wherein there is a conscious effort by the athlete/exerciser to synchronize their movements with the rhythmical qualities of music.

High-intensity activity with asynchronous music

A number of studies have examined the application of music during high-intensity activities and a range of benefits has been associated with both the asynchronous and synchronous applications of music. For example, Tenenbaum et al. (2004) used asynchronous music conditions of rock, dance, and "inspirational music" in apposition to a no-music control. These conditions did not impact upon endurance or perceptions of exertion during a high-intensity running task that was conducted on both a treadmill and on a cross-country course. The authors reasoned that the high intensity of the running tasks prevented participants from being able to derive benefit from the musical accompaniment. Nonetheless, relatively little attention was given to the selection of the music used.

Numerous studies have used cycle ergometer tasks in examining the effects of music. For example, Atkinson et al. (2004) played trance music to their participants while they engaged in a 10-km time trial and reported that it had an ergogenic effect during the first 3 km when perceptions of exertion were relatively low. RPE was higher during the music condition, which might be attributed to the fact that participants achieved finish times that were, on average, 22 s faster with music. Along similar lines, Hutchinson et al. (2011) administered a motivational music condition during a Wingate anaerobic cycle ergometer test and found that it increased peak and mean power relative to the control, while also positively influencing affect and self-reported state motivation.

Employing a 500-m rowing time trial, Rendi et al. (2008) reported that the fastest times were observed when participants listened to a fast-tempo excerpt from Beethoven's 7th symphony. Interestingly, a slow-tempo excerpt from the same symphony also resulted in faster completion times when compared to the control condition. Participants in this study reported that they had not previously used music in training; this may have elicited a novelty effect indicating the need for a habituation period. One recent study examined the effects of music on swimming using underwater MP3 players (Tate, Gennings, Hoffman, Strittmatter, & Retchin, 2012). The researchers found that self-selected music improved time trial performance in both sprint (50 m; ∼1% improvement) and long-distance freestyle swimming (800 m; ∼1% improvement). As the authors concede, self-selection of music presents a threat to internal validity as participants invariably select music that has a wide variety of psychoacoustic properties. Moreover, participants were not habituated to using the MP3 device and physiological measures were not taken to verify their workload across trials. Each of these limitations was addressed in the design of the present study.

High-intensity activity with synchronous music

Simpson and Karageorghis (2006) applied two synchronous music conditions (*motivational* and *oudeterous* [meaning motivationally neutral]) during a 400-m sprinting task. The motivational condition elicited faster times when compared against the no-music control, as did the oudeterous condition, albeit to a lesser degree (.9% vs. .4% improvements over control respectively). Hence, both the synchronization effect *and* the motivational qualities of the music appeared to benefit performance in this instance. Karageorghis et al. (2009) extended the 400-m study using a similar design to investigate the psychophysical and ergogenic effects of synchronous music during treadmill walking. Participants began the task at 75% of their maximum heart rate and continued until volitional exhaustion. Both motivational and oudeterous conditions elicited greater endurance than the no-music control (14.6% vs. 8.1% improvements over control respectively). The findings also showed that motivational music elicited higher affective valence scores to the point of voluntary exhaustion than oudeterous and control conditions, which yielded similar affective valence scores during the second half of the task.

Terry et al. (2012) used a treadmill running task comprised of three 4-min stages of progressively faster velocities and one maximal stage with a sample of elite triathletes. Participants were able to endure longer in the presence of two synchronous music conditions: self-selected motivational music, and an alternative that was neutral in its motivational qualities (18.1% vs. 19.7% improvements over control respectively). Furthermore, mood responses and feeling states were more positive under the motivational music condition compared to either the neutral or no-music conditions. A potential limitation in this study was that participants self-selected rap music which typically has a relatively slow tempo (80–110 bpm), and thus may not have been entirely appropriate given the high-arousal state engendered by the task (see Karageorghis et al., 2011).

Mechanisms underlying the effects of music during high-intensity activity

The mechanisms underlying the effects of music were expounded in a recent two-part review paper (Karageorghis & Priest, 2012a, 2012b) therefore only an overview will be provided here: The limited capacity of the nervous system has a bearing on the effects of music on attention (see Rejeski, 1985). These limitations restrict the degree to which the human organism is able to process music during high-intensity activity when fatigue-related signals overwhelm the afferent nervous system. Studies have demonstrated that, although music moderates RPE at low-to-moderate intensities of exercise, it does not moderate RPE at intensities beyond anaerobic threshold (e.g., Bharani, Sahu, & Mathew, 2004; Boutcher & Trenske,