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On the stability and relevance of the exercise heart rate–music-tempo preference relationship

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A B S T R A C T

Objectives: To examine the stability of the cubic (two points of inflection) exercise heart rate–music-tempo preference relationship found by Karageorghis et al. (2011) in cycle ergometry using a different exercise modality (treadmill exercise). To advance previous related studies through the inclusion of psychological outcome variables (e.g., state attention and intrinsic motivation) and post-experiment interviews.

Design: A mixed-model experimental design was employed with two within-subject factors (exercise intensity and music tempo) and a between-subjects factor (gender). The experiment was supplemented by qualitative data that were analyzed using inductive content analysis.

Methods: Participants ($n = 22$) exercised at six intensities (40–90% maxHRR) during which they were exposed to music tracks at four tempi and a no-music control. Music preference, affective valence, and perceived activation were assessed during the task. Immediately afterwards, an attentional focus item, the short Flow State Scale-2 and items from the Intrinsic Motivation Inventory were administered. A subsample of participants ($n = 8$) was interviewed using a schedule of open-ended questions.

Results: Results did not support a cubic relationship but rather a quadratic one (one point of inflection), and there was a weak association between the optimal choice of music tempo and positive psychological outcomes.

Conclusions: The range of preferred tempi for treadmill exercise (123–131 bpm) was narrower than that for cycle ergometry (125–140 bpm). Regardless of its tempo, music reduced the number of associative thoughts by ~10% across all exercise intensities.

There is a burgeoning literature on the psychophysical and ergogenic effects of music in the exercise domain (see Karageorghis & Priest, 2012a,b 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, Karageorghis, & Kinrade, 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). Through entrainment theory (Thaut, 2008, pp. 39–59) and associated empirical investigation, we have gained 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., 2008; 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, Jones, & Low, 2006; Karageorghis, Jones, & Stuart, 2008), Karageorghis and Terry (2009) argued that the relationship between physiological

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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 Fig. 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 (see Fig. 1)—that was observed in the Karageorghis et al. (2011) study can be 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., 2011) 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, 1985).

Using a sample of tennis players, Bishop et al. (2009) investigated how changes in the tempo and intensity of music influenced affective valence and subsequent choice-reaction task performance. Their results showed that fast-tempo music elicited emotional states that were more pleasant/arousing 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 intensity on self-selected speed of treadmill running. Fast music was associated with higher running velocities than either slow music or a white noise control. 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

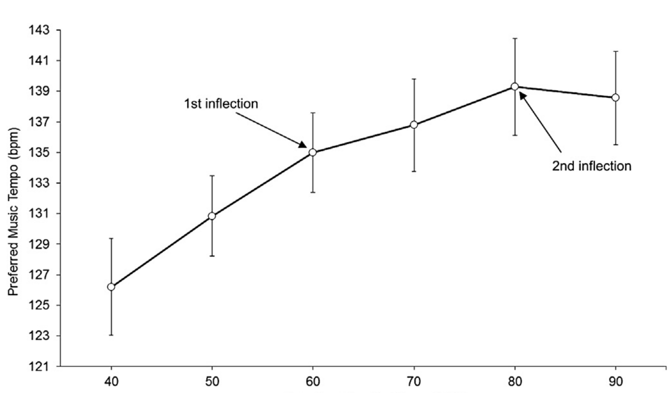

Fig. 1. The cubic relationship between exercise heart rate and preference for music tempo reported by Karageorghis et al. (2011). Reproduced with permission from *Research Quarterly for Exercise and Sport*, Vol. 82, No. 2, 274–284, Copyright (2011) by the American Alliance for Health, Physical Education, Recreation and Dance, 1900 Association Drive, Reston, VA 20191.

that music was selected only with consideration to tempo, and not other aspects that contribute to its motivational qualities, such as harmony, lyrics, and extramusical associations (Karageorghis, Terry, & Lane, 1999), which may have an impact on outcomes such as intrinsic motivation and flow (see e.g., Karageorghis et al., 2008).

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, Jones et al., 2006; Karageorghis et al., 2008; Karageorghis et al., 2011). Such formative 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, we do not fully comprehend the precise consequences of optimal music selection or poor selection at different exercise intensities.

Allied 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, Carr, & Orme, 2005). Also, given that Karageorghis et al. (2011) employed a simple motoric task (cycle ergometry) it is not known whether their findings are generalizable 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 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 Fig. 1) using a different exercise modality to that employed by Karageorghis et al. (2011) and to examine a number of psychological outcome variables (e.g., affective valence and state attention). Thus the present study is more ambitious in scope than the preceding three studies (Karageorghis, Jones et al., 2006; Karageorghis et al., 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 generalize 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).

It was hypothesized 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 most positive psychological outcomes would be associated with the most appropriate tempo for each intensity (see Fig. 1). 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, Jones et al., 2006; Karageorghis et al., 2008, 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_2). We included gender as an independent variable in our analyses but did not expect any gender differences to emerge (H_3).