Relationship Between Exercise Heart Rate and Music Tempo Preference

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Abstract

The present study examined the predicted positive and linear relationship (Iwanaga, 1995a, 1995b) between exercise heart rate and music tempo preference. Initially, 128 undergraduates (M age = 20.0 years, SD = 0.9 years) were surveyed to establish their three favorite music artists of all time. A separate experimental group of 29 undergraduates (M age = 20.3 years, SD = 1.2 years) selected the music of a single artist from a choice of the three highest-rated artists from the earlier survey. They reported their preference for slow, medium, and fast tempo music selections from the same artist in each of three treadmill walking conditions at 40%, 60%, and 75% maximal heart rate reserve. A mixed-model 3 x 3 x 2 (Exercise Intensity x Music Tempo x Gender) analysis of variance was used to analyze the data. Results indicated there was no three-way interaction for music preference. There was however a significant ($p < .05$) two-way interaction for Exercise Intensity x Music Tempo (partial $\eta^2 = .09$) and a significant ($p < .05$) main effect for music tempo, with large differences evident between preference for medium tempo versus slow tempo and fast tempo versus slow tempo music at all exercise intensities (partial $\eta^2 = .78$). Participants reported a preference for both medium and fast tempo music at low and moderate exercise intensities, and for fast tempo music at high intensity. Only partial support was found for the expected linear relationship between exercise intensity and music tempo preference.

Key words: music speed, rhythm response, treadmill walking

Relationship Between Exercise Heart Rate and Music Tempo Preference

The use of music in sport and exercise contexts has attracted considerable interest from researchers in recent years (e.g., Karageorghis, Terry, & Lane, 1999; Szabo, Small, & Leigh, 1999; Tenenbaum, Lidor, Lavyan, et al., 2004) and it has long been considered an effective means by which to enhance the exercise experience (see Karageorghis & Terry, 1997, for a review). Poorly designed studies and lack of an underlying theoretical framework blighted much of the early research work in this area. These problems were addressed in part by Karageorghis and Terry (1997), who provided guidelines on study design, and Karageorghis et al. (1999), who developed a conceptual framework for the assessment of the motivational qualities of music in sport and exercise.

In their conceptual framework, Karageorghis et al. (1999) proposed that four factors contribute to the motivational qualities of a piece of music: (a) rhythm response, (b) musicality, (c) cultural impact, and (d) association. Rhythm response relates to the musical rhythm, most notably tempo (speed of music as measured in beats per minute), whereas musicality is the response to pitch-related elements, such as harmony and melody. Cultural impact refers to the pervasiveness of the music within society, and association pertains to the extra-musical associations that a piece may evoke (e.g., Vangelis's 'Chariots of Fire' with Olympic glory). The factors exhibit a hierarchical structure (i.e., rhythm response is the most important, while association is the least important contributor to the motivational quotient of a piece of music).

Tempo is considered to be the most significant determinant of musical response (Brown, 1979; Budd, 1985; Hevner, 1935; Karageorghis et al., 1999). Berlyne (1971) predicted a curvilinear relationship between preference and tempo. A review by Bruner (1990) supported this; however, the listener's physiological arousal and the context in which the music is heard may affect the tempo preference (North & Hargreaves, 1997), meaning that as physiological arousal increases, one should, accordingly, prefer higher tempi. Neuropsychologists have asserted that the optimal speed at which humans are able to process rhythmical stimuli may influence preferred tempo (Carroll-Phelan & Hampson, 1996). Fast tempi and strong rhythms may contribute to preference, because they are inherently stimulative (Gaston, 1951). Therefore, Berlyne's (1971) proposal, that the arousal potential of stimuli determines preference, appears intuitively appealing. The implication is that during physical activity there will be stronger preferences for fast tempo music, owing to increases in physiological arousal.

A body of research has tested the hypothesis that people prefer auditory stimuli with tempi in the range of the normal patterning of heart rate during everyday activity (i.e., 70-100 bpm). For example, Iwanaga (1995a) asked participants to search for their favorite tempo by self-regulation of a 440 Hz pure tone, and as expected, the preferred tempi were close to heart rate. To extend this to a musical stimulus, Iwanaga (1995b) examined the relationship between heart rate and music tempi preferences. Participants controlled musical tempo using a computer. Results confirmed a significant positive relationship between preferred tempo and heart rate.

Iwanaga's (1995a, 1995b) work was criticized by LeBlanc (1995), who argued that the methodologies were unrepresentative of those used in traditional music research and generally lacking in external validity. Specifically, in normal circumstances, listeners are seldom able to alter the tempo of a piece of music to which they are listening. Rather, most judgments of tempo preference are made post hoc. Traditional music research (e.g., LeBlanc, Colman, McCrary, Sherrill, & Mallin, 1988; LeBlanc & McCrary, 1983) indicates that listeners generally prefer faster tempi than heart rates for people at rest or performing normal activity. Further, research consistently shows that the younger participants are the faster their preferred tempi (LeBlanc, 1982; LeBlanc et al., 1988). LeBlanc (1995) suggested that Iwanaga's findings could be validated through having the same group of participants select their preferred tempi at different work intensities. If the same participants preferred tempi close to their heart rates in a range of conditions at different work intensities, it would offer strong support for Iwanaga's hypothesis and subsequent findings.

Using a questionnaire approach, research (Karageorghis, Terry, & Lane, 1999; Priest, Karageorghis, & Sharp, 2004), has shown that women exhibit a stronger preference than men for the rhythmical qualities of music. It is, therefore, plausible that, owing to their greater exposure to dance and movement-to-music during their formative years (see Pellett, 1994), women will show a more marked preference for music with a tempo that is linked to their exercise intensity. It is also plausible that this preference is reinforced in later life through attendance of exercise-to-music classes. Hence, the purpose of the present study was to extend the work of Iwanaga (1995a, 1995b) to examine the relationship between exercise intensity and music tempo preference using three work intensities (40%, 60% and 75% of maximal heart rate reserve: maxHRR) and music at 80, 120 and 140 beats per minute (bpm) between genders. Such work is valuable insofar as knowing how the impact of exercise intensity impacts on music preference will allow practitioners to tap the ergogenic and psychophysical effects of music with greater precision.

It was hypothesized that, in accordance with previous findings (Iwanaga, 1995a, 1995b), there would be a positive linear relationship between exercise intensity and music tempo preference, with women exhibiting a more pronounced response to changes in music tempo. More specifically, through an interaction approach, it was predicted that: (a) preference for slow tempo music would be highest at 40% maxHRR and lowest at 75% maxHRR; (b) preference for medium tempo music would be highest at 60% maxHRR and lowest at 40% maxHRR and 75% maxHRR; and (c) preference for fast tempo music would be lowest at 40% maxHRR and highest at 75% maxHRR. It was also hypothesized that, because young adults were tested, the preference ratings for slow tempo music would be significantly lower than preferences for both medium and fast tempo music at all exercise intensities.

Method

Stage 1: Music Selection

Participants and Procedure. A sample of 128 volunteer sports science undergraduates (67 women and 61 men, *M* age = 20.0 years, *SD* = 0.9 years) who were Caucasian and brought up in the United Kingdom, was used to identify the music used in Stage 2 of the experimental protocol. It was intended that these students matched the profile of the intended pool of experimental participants both in terms of age and sociocultural background (cf. Karageorghis & Terry, 1997). Although the choice of this sample aided maintenance of internal validity, it did limit generalizability to other subgroups of the population of British undergraduates. All participants in the present study provided written informed consent.

Participants were asked to record their three favorite music artists of all time on a response sheet in hierarchical order. Subsequently, the three highest-rated artists representing the women's favorite (Christina Aguilera), the men's favorite (The Stereophonics), and the favorite across genders (Michael Jackson) were used. The Brunel Music Rating Inventory (BMRI: Karageorghis et al., 1999), was used to rate three tracks at slow, medium, and fast tempi from each artist (nine tracks total) to assess their motivational qualities. The four rhythm response items were omitted, as tempo, an integral element of rhythm, was an independent variable in the present design. Although the tempi between tracks for each artist differed, this procedure was undertaken to ensure homogeneity in the motivational qualities of the music, so it would not compromise internal validity.

A panel of six undergraduate sports science students (3 women and 3 men, *M* age = 20.8 years, *SD* = 0.4 years) rated 27 tracks using the BMRI. This panel also matched the profile of the intended pool of experimental participants in terms of age and sociocultural background. Specifically, they rated the motivational qualities of each track with reference to a treadmill-walking task according to the instructions of Karageorghis et al. (1999). Tracks that had similar motivational quotients at each of the three required tempi (80, 120 and 140 bpm) were recorded onto CDs in counterbalanced order. Therefore, nine CDs were created (three artists x three tempi), each containing three tracks from one of the three selected artists. The tracks from each artist were also recorded in counterbalanced order. Copyright permission was requested from the music publishers to record the tracks for research purposes, and full details are presented in Table 1.

Stage 2: Experimental Investigation

Power Analysis. A power analysis was conducted to establish appropriate sample size. With alpha set at .05 and power at .8 to protect beta at four times the level of alpha (Cohen, 1988), based on an estimated moderate effect size (partial $\eta^2 = 0.08$) for the exercise intensity x music tempo preference interaction (cf. Iwanaga, 1995b), it was calculated that approximately 28 participants would be required. There were no experimental data to inform the expected effect size for the gender difference explored in the present analysis.

Participants. Twenty-nine volunteer participants comprising 14 women (*M* age = 20.4 years, *SD* = 1.3 years) and 15 men (*M* age 20.3 years, *SD* = 1.1 years) were selected from the body of sports science undergraduates at Brunel University. All were Caucasians brought up in the United Kingdom. The research team strove to ensure that participants were homogeneous in terms of their age and sociocultural background, as these are deemed to be key factors that impact upon reactivity to music (Karageorghis & Terry, 1997; Lucaccini & Kreit, 1972). Participants were drawn from outfield positions in weight-bearing sports (e.g., rugby union, soccer, netball, field hockey, etc.) to maintain some homogeneity in terms of their aerobic fitness and suitability for treadmill walking. An inducement was used to recruit participants. Specifically, their names were entered into a draw for an item of sports apparel, with separate draws conducted for women and men.

Apparatus and Measures. A treadmill (Powerjog GXC200) was used for testing along with a CD player (Philips AZ2555, Philips Electronics, Cambridge, UK) and a decibel meter (GA 102 Sound Level Meter Type 1; Castle Associates, Scarborough, UK) to standardize music intensity. Target heart rate was assessed by use of a heart rate monitor (Polar Accurex Plus; Polar, Kempele, Finland) and a sensor held by the experimenter. Music preference at each of the three work intensities was assessed using a single item: “Rate your preference for this track based on your current work level” with responses provided on a 10-point scale anchored by 1 (“I do not like it at all”) and 10 (“I like it very much”).

Pre-test and Habituation Trial. Ethical clearance was obtained for the study, following adherence to procedures stipulated by the Brunel University Ethics Committee. It was necessary for participants to walk on a treadmill at speeds corresponding with 40%, 60%, and 75% maxHRR. These were established as appropriate exercise intensities to differentiate preference between varying musical tempi without requiring participants to work at intensities involving significant anaerobic contribution to the overall energy expenditure. It has been shown that music is much less effective as a dissociation tool or ergogenic aid at high exercise intensities (Boutcher & Trenske, 1990; Tenenbaum et al., 2004). This is due to the preeminence of internal sensations of fatigue in determining perceived exertion (cf. Rejeski’s 1985 parallel information processing model). To establish participants’ maximal heart rate, they were required to complete a Multistage Fitness Test (MFT: Brewer, Ramsbottom, & Williams, 1988). The MFT entails a 20-

m progressive shuttle run in which participants run in time to a prerecorded bleep. The bleep increases in frequency at the beginning of each minute and the longer participants are able to endure the test, the higher their aerobic capacity. The MFT was selected, because all Brunel University undergraduates participating in weight-bearing sports had experience with it, as the test is used regularly to measure aerobic capacity. Thus, they were very familiar with the pretest protocol.

Participants received detailed verbal instructions on completing the MFT. They wore a heart rate monitor on their chest and a sensor on the wrist on which they would normally wear a watch. Participants were instructed that when they could no longer able to keep in time with the beeps, they should call out the heart rate reading displayed on the sensor to a member of the research team. The mean maximal heart rate obtained was 186.10 bpm (*SD* = 6.22 bpm). In calculating the exercise heart rate for each of the three work intensities (40%, 60%, and 75% maxHRR), heart rate reserve was established (see McArdle, Katch, & Katch, 2001) using the Karvonen formula (Karvonen, Kentala, & Mustala, 1957) to standardize work intensity across participants.

The second stage involved habituating each participant to the treadmill-walking task. The treadmill gradient was altered to increase exercise intensity rather than its velocity. The rationale for this procedure was to control for any potential synchronization effect of stride rate with music tempo (Anshel & Marisi, 1978; Mertesdorf, 1994). Participants spent approximately 20 min on the treadmill during the habituation trial, during which the experimental protocol was explained thoroughly.

Experimental Trial. Three experimental conditions scheduled for each participant over consecutive weeks. Conditions comprised of walking at 40%, 60%, and 75% maxHRR. Participants were required to follow identical patterns of activity and diet with no other vigorous physical activity permitted prior to the trial on each test days. Further, they were not permitted to eat a meal within two hours prior to testing. The order of conditions was randomized for each participant, and they engaged in the experiment individually.

At the first test session, participants were given a choice of the three artists who were earlier rated by their peers. While walking on the treadmill, participants were instructed to look straight ahead at a large blank screen positioned immediately in front of them. The rationale for this was to negate the influence of any visual stimuli on their responses to the music. A decibel meter was used to standardize music intensity at 75 dB for each of the nine tracks. This upper level intensity would typify most exercise facilities but still lie within safe limits from an audiological perspective (Alessio & Hutchinson, 1991).

Participants performed a 2-min warm-up at a speed of 4.5 kph with no music and then at a constant 6 kph for the duration of the test. During earlier piloting of the protocol, it was found that 6 kph would facilitate fast walking without forcing participants to break into a run. The experimenter then administered the appropriate exercise intensity by raising the gradient of the treadmill until the participant reached target heart rate and maintained it for 1 min. On each test day, three tests were administered using music preference of selections from a single artist at three different tempi (80, 120, and 140 bpm) and at a single exercise intensity. The same artist(s) was/were used in order to maintain the internal validity of the study, given that the artist(s) could have a significant impact in determining music preference (Boyle, Hosterman, & Ramsey, 1981; Karageorghis et al., 1999).

All musical selections included one verse and one chorus and were approximately 1.5 min in duration. Further, when tracks deviated slightly from the required tempi, they were digitally altered during recording to correspond with the required tempo. Any alterations were so small as to not be discernible. Ten seconds before the end of each track, participants were asked to rate their preference for the piece of music based on their current work level. The order of track presentation was randomized to avoid response bias. In between each track, a technique known as a “filler” (Bargh & Chartrand, 2000) was employed to facilitate active attentional manipulation so that the impact of one track would not carry over to the next and present a threat to internal validity. The filler comprised a mental arithmetic task that required participants to recite either the 9 or 12 times table backwards. Participants were informed that no penalties would be incurred for poor performance on this task. The entire procedure was repeated until the three tracks from the same artist were rated. The same artist(s) was/were used for the subsequent two trials, which were administered on different days. Participants performed a 2-min warm down at the end of each trial. The total time each participant on the treadmill during each experimental trial was approximately 12 min.

Data Analysis

Data were screened for univariate outliers using z scores > $\pm$ 3.29 and then for multivariate outliers using the Mahalanobis distance method with $p < .001$ (Tabachnick & Fidell, 2001). There was a single dependent variable—music preference—and three independent variables: exercise intensity (40%, 60%, and 75% maxHRR), music tempo (slow, medium, and fast), and gender. Thus, following checks to ensure the data were suitable for parametric analysis, a mixed-model 3 x 3 x 2 (Exercise Intensity x Music Tempo x Gender) analysis of variance was applied.

Results

Checks for outliers revealed no univariate or multivariate outliers. Tests of the distributional properties of the data in each analysis cell revealed minor violations of normality in 7 of the 35 cells (all at $p < .05$; see Table 2): At 40% maxHRR, the preference scores of men responding to medium tempo exhibited significant positive skewness; at 40% maxHRR, the combined scores of women and men responding to medium tempo music exhibited significant positive skewness; at 75% maxHRR, the preference scores of women responding to medium tempo exhibited significant negative skewness and positive kurtosis; at 75% maxHRR, the combined scores of women and men responding to medium tempo music exhibited significant positive skewness; and at 75% maxHRR, the combined scores of women and men responding to fast tempo music exhibited significant negative skewness. Also, women exhibited significant negative skewness in their music preference scores independent of exercise intensity and music tempo. Keppel (1991) indicated that ANOVA is sufficiently robust to withstand such minor violations of normality, and thus, a decision was taken not to apply logarithmic transformation. Mauchly's test of sphericity was non-significant, Mauchly's $W = .59$, $p > .05$. Collectively, the diagnostic tests indicated that the assumptions underlying a three-way mixed-model ANOVA were satisfactorily met and that the results would be generalizable to the population of participants.

Interaction Effects

The higher-order interaction of Exercise Intensity x Music Tempo x Gender was non significant ($p > .05$) as were the two-way interactions of Exercise Intensity x Gender and Music Tempo x Gender (see Table 2). However, as expected, there was a significant two-way interaction for Exercise Intensity x Music Tempo (see Table 2 and Figure 1), $F(4,108) = 2.79$, $p < .05$, which yielded a moderate effect size (partial $\eta^2 = .09$). More specifically, follow-up within-subjects contrasts, $F(1,27) = 12.60$, $p < .01$, indicated that the preferences for medium vs. fast tempo music differed significantly at 75% maxHRR, with a decrease in preference for medium tempo music when compared against fast tempo, and the medium tempo music at 60% maxHRR (partial $\eta^2 = .32$).

Collectively, the interaction effects revealed that gender did not moderate the relationship between working heart rate and music tempo preference. Preference for fast tempo music was high during all exercise intensities but significantly more so during high-intensity exercise. The preference for medium tempo music remained stable at low and moderate exercise intensities but decreased significantly during high-intensity exercise. Finally, the slow tempo music was least preferred, and preference for it did not change in response to different exercise intensities.

Main Effects

The main effects indicated no significant ($p > .05$) differences in music tempo preference across the three exercise intensities or between genders (see Table 2). There was, however, a significant ($p < .05$) main effect for music tempo with a very large effect size (partial $\eta^2 = .78$). Follow-up multiple comparisons with Bonferroni adjustment indicated that participants preferred fast tempo music to slow tempo music, 95% Confidence Interval = 2.01 – 3.26, $p < .001$, and medium tempo music to slow tempo music, 95% confidence interval = 1.74–2.96, $p < .001$.

Discussion

The main aim of the present study was to examine the link between exercise intensity and music tempo preference. A secondary aim was to explore whether any observed relationship was moderated by gender. Results indicated that, in partial support of the primary hypothesis, there was a corresponding increase in preference for fast tempo music as work intensity increased; however, this transpired only during high intensity exercise (75% maxHRR). Contrary to the research hypothesis, preference for slow music remained stable across the three exercise intensities, while the medium tempo preference scores did not significantly exceed those for fast tempo at low and moderate exercise intensities.

The hypothesis pertaining to gender moderating the exercise heart rate-preferred music tempo relationship was refuted, given that, in contrast to suggestions made in previous work

(Karageorghis et al., 1999), gender exerted no influence on music tempo preference. Overall, fast and medium tempo music was preferred over slow music at all exercise intensities, while participants reported a preference for fast music over medium tempo music at the high exercise intensity only. Further, the preference rating for medium tempo music decreased from the moderate- to high intensity conditions as predicted.

Exercise Intensity and Music Tempo Preference

A strength of the present study was that an attempt was made to standardize the potential impact of the music in all aspects other than tempo. Thus, tracks from the same artist were used and these tracks were similar in terms of their motivational qualities, as rated using the BMRI. Music was selected with reference to the sub-culture/age-group preferences of the experimental participants in line with previous recommendations (Karageorghis & Terry, 1997). Also raising the gradient of the treadmill to increase exercise intensity, rather than increasing its velocity, controlled for the commonly observed phenomenon of synchronization (Anshel & Marisi, 1978; Mertesdorf, 1994). In support of the conceptual model Karageorghis et al. (1999) and the suggestions of several other authors (Brown, 1979; Budd, 1985; Hevner, 1935; North & Hargreaves, 1997), tempo appeared to have a profound influence on music preference, regardless of exercise intensity. This provides empirical support for the notion that, during exercise, higher tempi are preferred to slower tempi. This observation can be attributed to at least one of three underlying mechanisms. First, higher tempo music is preferred during exercise, because it reflects participants' the physiological arousal level (Berlyne, 1971; North & Hargreaves, 1997). Second, young adults prefer higher tempo music regardless of their physiological arousal level (Gfeller, 1988; LeBlanc, 1982; LeBlanc et al., 1988; Priest et al., 2004). Third, people are conditioned to respond positively to fast tempo music during exercise owing to its ubiquity in such environments (North & Hargreaves, 1997).

The expected interaction between exercise intensity and music tempo preference did not emerge to the extent predicted. However, it is apparent that during high-intensity exercise (75% maxHRR) there was a significantly stronger preference for fast tempo music compared to medium tempo. Follow-up analyses indicated that this interaction yielded a very large effect size ($\eta^2 = .32$). The highest mean value for music preference, ($M = 7.38$, $SD = 1.18$, was recorded during high-intensity exercise when participants listened to fast tempo music. Notably, this finding suggests participants had a particularly gratifying listening experience in this condition. In contrast to expectations, participants did not discriminate in terms of preference between medium and fast tempo music at either low or moderate exercise intensities. This indicates that grades of exercise intensity up to a moderate level (60% maxHRR) can be accompanied by music in the range 120-140 bpm without any degradation in preference; this is also the tempo range of most commercial dance music. Medium and fast tempo music is most suitable at low to moderate exercise intensities.

The present study did not set out to test Berlyne's (1971) theory in its entirety (i.e., specifically that there would be a curvilinear relationship between preference and tempo), as the tempi conditions were selected to correspond with the three exercise intensities. Thus, a logical extension of the present design would be to test more up-tempo conditions during high intensity exercise, perhaps at 150, 160 and 170 bpm, to ascertain whether the predicted curvilinear relationship transpires in response to higher tempi. This, however, present the challenge of finding appropriate music selections that concur with the preferences and socio-cultural background of participants. In Western music, only folk, jazz, and classical music provide a full range of tempi, and exercise participants, particularly those less than 45 years of age, generally do not prefer these styles (Gfeller, 1988; Priest et al., 2004).

Results supported the hypothesis that there would be a significantly greater preference for medium and fast tempo music compared to slow music, but there were no differences for slow tempo between the three exercise intensities. This was part of the interaction effect expected to emerge. The present data suggest that slow music is inappropriate for repetitive exercise, irrespective of exercise intensity. Further, the lack of an interaction indicates that slow tempo music was universally least preferred (*M* preference = 4.51, *SD* = 1.09) and that this preference did not vary with exercise heart rate. The implication of this finding is that medium and fast tempo music should be played in British gymnasia, particularly where the majority user group comprises of Caucasian young adults. However, practitioners should be mindful of the fact that when working with individual clients, a switch from slow to fast tempo music may engender an ergogenic effect (see Szabo et al., 1999). There is scope for further research into preference for tempo variation of asynchronous music. From recent literature, a clear picture is emerging with regard to the impact of individual components of music such as tempo and style (Priest et al., 2004), but we do not yet have a strong empirical basis for the structure of an entire music program in exercise.

Other recommendations that emanating from the present findings concern how music tempo might impact upon aspects of exercise behavior, most notably initiation and adherence. First, given that the arousal potential of stimuli determines preference (Berlyne, 1971), and that individuals often require a moderate increase in arousal to initiate physical activity (Oxendine, 1984), it follows logically that listening to music of a medium tempo prior to exercise will assist participants in attaining an optimal mindset. Moreover, if such music contains lyrical affirmations pertaining to aspects of motivation (e.g., “work your body” or “search for the hero inside yourself”), it will have an even more potent effect (Karageorghis & Terry, 1997; Karageorghis et al., 1999; Priest et al., 2004). Second, given the burgeoning evidence surrounding the impact of in-task affect and enjoyment on adherence (e.g., Motl, Dishman, Saunders, Dowda, Felton, & Pate, 2001; Sallis, Prochaska, Taylor, Hill, & Geraci, 1999; Vlachopoulos & Karageorghis, 2005), musical accompaniment that induces positive affect and promotes enjoyment is likely to increase levels of adherence.

A minor limitation of the present study was that experimental participants with a mean age of 20.3 years achieved a maximal heart rate of only 186.10 bpm on the MFT. They were expected to reach maximal heart rates closer to 200 bpm (McArdle et al., 2001), so this does raise concern over their level of motivation during the pretest. However, given that a repeated measures analysis was used and participants acted as their own controls, this minimized the impact of their apparent underperformance in the MFT. Future studies could overcome this limitation by employing a standard treadmill protocol to induce maximal heart rate, such as the Bruce or Balke protocol, alongside other objective measures of maximal physical exertion such as ratings of perceived exertion, oxygen uptake, the respiratory exchange ratio, and blood lactate levels. Such additional measures would minimize any potentially confounding influence low motivation might have on the achievement of maximal exercise performance.

The Moderating Effect of Gender

The hypothesis pertaining to the expected moderation effect of gender in the exercise intensity-music tempo preference relationship was refuted. This part of the analysis was somewhat exploratory in nature, given that the gender moderation effect has not been previously tested. Although it has been suggested that women are more attuned to the rhythmical aspects of music, because of the superior early life music-movement experiences (Karageorghis et al., 1999; Pellett, 1994), tempo is only one aspect of rhythm.

A limitation of the present study is that even though tempo was tightly controlled, it was difficult to standardize *accentuation* in the music across exercise intensities (i.e., the other element impacting upon a rhythm response), which concerns the periodic organization of sound. The upshot of this is that although women may be more sensitive to the rhythmical qualities of music, they may well be more attuned to the accentuation aspect of rhythm. Although tempo determines how fast one might dance, or one's speed of movement in an aerobic dance exercise class, it does not determine the *pattern* of movement; this is determined by accentuation.

According to the present findings, women and men appear to be equally sensitive to changes in tempo in terms of their music preferences. To standardize accentuation across conditions, the same piece of music would need to be played at different tempi. However, this approach would limit the external validity of the experiment (cf. LeBlanc, 1995), as people rarely listen to the same piece of music at different tempi. Finally, any potential gender differences may appear more salient through investigating synchronous music, given that women use synchronous music to a greater extent in an exercise context (Karageorghis et al., 1999).

Conclusions and Recommendations

The present study offers the first experimental attempt to investigate the relationship between exercise heart rate and music preference. The potential moderating effect of gender in this relationship was also tested. Results indicated that, in partial support of the primary research hypothesis, fast tempo music was preferred to medium tempo and slow tempo music at the high exercise intensity of 75% maxHRR. In support of the secondary research hypothesis, preference ratings for both fast and medium tempi were higher than ratings for slow tempo music at low, moderate, and high exercise intensities. The expected interaction between exercise intensity and music tempo preference did not emerge at the low and moderate exercise intensities, while gender did not moderate the exercise heart rate-preferred music tempo preference relationship.

Collectively, the present findings indicate that at exercise intensities up to 60% maxHRR, participants prefer music in the range 120–140 bpm. At 75% maxHRR, fast tempo music (140 bpm) is preferred, while even at a low exercise intensity, slow music appears to be an inappropriate accompaniment for motoric, rhythmical, and repetitive exercise. There was a moderate positive relationship between exercise intensity and music tempo preference (partial $\eta^2 = .09$). Exercise practitioners need to be cognizant of the fact that slow tempo music may reduce the quality of the exercise experience, while fast tempo music should be the primary choice for high intensity exercise, particularly with British Caucasian young adults. Beyond this, it is also important to select music with reference to the idiomatic preferences and socio-cultural background of exercise participants (Karageorghis & Terry, 1997; Lucaccini & Kreit, 1972).

The low preference ratings for slow music, even at low exercise intensity, indicate that participants should listen to music of a medium tempo prior to initiating exercise. This recommendation stems from the notion that there is an expectancy effect relating to music tempo in exercise environments (North & Hargreaves, 1997) and that the tempo will engender an appropriate level of arousal for initiation of exercise. Further, the match of music at an appropriate tempo *during* exercise is most likely to induce positive in-task affect and promote enjoyment. These psychological factors play a critical part in determining exercise adherence (Motl et al., 2001; Sallis et al., 1999; Vlachopoulos & Karageorghis, 2005).

In terms of future research, although the present findings can be generalized to Caucasian young adults in the United Kingdom, there is a need to examine the responses of other ethnic groups and age groups, most notably older adults, whose preferences gravitate toward softer and slower music (Gfeller, 1988; Priest et al., 2004). Also, the curvilinear relationship between music tempo and preference proposed by Berlyne (1971) warrants investigation in an exercise context. The finding that gender did not moderate music tempo preference should be reinvestigated, as the accentuation aspect of the rhythm response was not standardized across conditions in the present study.

Researchers need to address the construction of music programs, given that individual pieces are most often combined in a “mix” that is subsequently played on a “loop”. Although the present findings ostensibly serve to extol the virtues of fast tempo music during repetitive exercise, it is currently not known whether continual exposure to such music results in negative affective responses such as boredom and irritation. Hence, to maximize affective responses to music, a variation in tempo may be the optimal solution within a certain bandwidth of tempi. Finally, given that the present study was conducted under tight experimental conditions to maintain internal validity, it would be logical to extend examination of the exercise heart rate-preferred music tempo relationship to more ecologically valid settings.

References

Anguilera, C., & Storch, S. (2002). Fighter. *On Stripped* [CD]. New York: RCA Records.

Alessio, H. M., & Hutchinson, K. M. (1991). Effects of submaximal exercise and noise exposure on hearing loss. *Research Quarterly, 62,* 413-419.

Anshel, M. H., & Marisi, D. Q. (1978). Effects of music and rhythm on physical performance. *Research Quarterly, 49,* 109-113.

Ballard, G. (2001). Keep the faith [Recorded by M. Jackson]. On *Dangerous (remastered)* [CD]. London: Sony Music. (1991)

Bargh, J. A., & Chartrand, T. L. (2000). The mind in the middle: A practical guide to priming and automaticity research. In H. Reis & C. Judd (Eds.), *Handbook of research methods in social psychology* (pp. 253-285). New York: Cambridge University Press.

Berlyne, D. E. (1971). *Aesthetics and psychobiology*. New York: Appleton Century Crofts.

Boutcher, S. H., & Trenske, M. (1990). The effects of sensory deprivation and music on perceived exertion and affect during exercise. *Journal of Sport and Exercise Psychology, 12,* 167-176.

Boyle, J. D., Hosterman, G. L., & Ramsey, D. S. (1981). Factors influencing pop music preferences of young people. *Journal of Research in Music Education, 29,* 47-55.

Brewer, J., Ramsbottom, R., & Williams, C. (1988). *Multistage Fitness Test: A progressive shuttle-run test for the prediction of maximum oxygen uptake*. Leeds, England: National Coaching Foundation.

Brown, P. (1979). An enquiry into the origins and nature of tempo behaviour: II. Experimental work. *Psychology of Music, 9,* 32-43.

Bruner, G. C. (1990). Music, mood and marketing. *Journal of Marketing, 54,* 94-104.

Budd, M. (1985). *Music and the emotions: The philosophical theories*. London: Routledge and Kegan Paul.

Carroll-Phelan, B., & Hampson, P. J. (1996). Multiple components of the perception of musical sequences: A cognitive neuroscience analysis and some implications for auditory imagery. *Music Perception, 13,* 517-561.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Gaston, E. T. (1951). Musical factors influencing social behavior. *Kansas Welfare Digest, 10,* 2-4.

Gfeller, K. (1988). Musical components and styles preferred by young adults for aerobic fitness activities. *Journal of Music Therapy*, *25*, 28-43.

Hevner, K. (1935). Expression in music: A discussion of experimental studies and theories. *Psychological Review, 42,* 186-204.

Iwanaga, I. (1995a). Relationship between heart rate and preference for tempo of music. *Perceptual and Motor Skills, 81,* 435-440.

Iwanaga, I. (1995b). Harmonic relationship between preferred tempi and heart rate. *Perceptual and Motor Skills, 81*, 67-71.

Jackson, M. (2003). Beat it. On *Number ones* [CD]. London: Sony Music. (1982)

Jones, K. (1997). Last of the big time drinkers. On *Word gets around* [CD]. London: V2 Music.

Jones, K. (1999). Half the lies you tell ain't true. On *Performance and cocktails* [CD]. London: V2 Music.

Jones, K. (2001). Caravan holiday. On *Just enough education to perform* [CD]. London: V2 Music.

Karageorghis, C. I., & Terry, P. C., (1997). The psychophysical effects of music in sport and exercise: A review. *Journal of Sport Behavior, 20,* 54-68.

Karageorghis, C. I., Terry, P. C., & Lane, A. M. (1999). Development and validation of an instrument to assess the motivational qualities of music in exercise and sport: The Brunel Music Rating Inventory. *Journal of Sports Sciences, 17,* 713-724.

Karvonen, M. J., Kentala, E., & Mustala, O. (1957). The effects of training heart rate: A longitudinal study. *Annals Medicinae Experimentalis et Biologiae Fenniae, 35,* 307-315.

Keppel, G. (1991). *Design and analysis: A researcher's handbook* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.

LeBlanc, A. (1982). An interactive theory of music preference. *Journal of Music Therapy, 19,* 28-45.

LeBlanc, A., & McCrary, J. (1983). Effect of tempo on children's music preference. *Journal of Research in Medicine, 31,* 283-294.

LeBlanc, A., Coleman, J., McCrary, J., Sherrill, L., & Malin, S. (1988). Tempo preference of different age listeners. *Journal of Research in Music Education, 36,* 156-168.

LeBlanc, A. (1995). Differing results in research in preference for music tempo. *Perceptual and Motor Skills, 81,* 1253-1254.

Lucaccini, L. F., & Kreit, L. H. (1972). Music. In W. P. Morgan (Ed.), *Ergogenic aids and muscular performance* (pp. 240-245). New York: Academic Press.

McArdle, W. D., Katch, F. I. & Katch, V. L. (2001). *Exercise physiology: Energy, nutrition and human performance* (5th ed.). London: Williams and Wilkins.

Mertesdorf, F. L. (1994). Cycle exercising in time with music. *Perceptual and Motor Skills, 78,* 1123-1141.

Motl, R. W., Dishman, R. K., Saunders, R., Dowda, M., Felton, G., & Pate, R. R. (2001). Measuring enjoyment of physical activity in adolescent girls. *American Journal of Preventive Medicine, 21,* 110-117.

North, A. C., & Hargreaves, D. J. (1997). The musical milieu: Studies of listening in everyday life. *The Psychologist, 10*(7), 309-312.

Oxendine, J. B. (1984). *Psychology of motor learning* (2nd ed.). Englewood Cliffs, NJ: Prentice Hall.

Pellett, T. L. (1994). Children's stereotypical perceptions of physical activities: A K-12 analysis. *Perceptual and Motor Skills, 79,* 1128-1130.

Perry, L. (2002). Beautiful [Recorded by C. Aguilera]. On *Stripped* [CD]. New York: RCA Records.

Priest, D. L., Karageorghis, C. I., & Sharp, N. C. C. (2004). The characteristics and effects of motivational music in exercise settings: The possible influence of gender, age, frequency of attendance, and time of attendance. *Journal of Sports Medicine and Physical Fitness, 44*, 77-86.

Rejeski, W. J. (1985). Perceived exertion: An active or passive process? *Journal of Sport Psychology, 75*, 371-378.

Sallis, J. F., Prochaska, J. J., Taylor, W. C., Hill, J. O., & Geraci, J. C. (1999). Correlates of physical activity in a national sample of girls and boys in grades 4 through 12. *Health Psychology, 18,* 410-415.

Szabo, A., Small, A., & Leigh, M. (1999). The effects of slow- and fast-rhythm classical music on progressive cycling to voluntary physical exhaustion. *Journal of Sports Medicine and Physical Fitness, 39(3)*, 220-225.

Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4th ed). Needham Heights, MA: Allyn and Bacon.

Temperton, R. L. (2003). Thriller [Recorded by M. Jackson]. On *Number ones* [CD]. London: Sony Music. (1982)

Tenenbaum, G., Lidor, R., Lavyan, N., Morrow, K., Tonnel, S., Gershgoren, A., et al. (2004). The effect of music type on running perseverance and coping with effort sensations. *Psychology of Sport and Exercise*, *5*, 89-109.

Vlachopoulos, S. P., & Karageorghis, C. I. (2005). Interaction of external, introjected, and identified regulation with intrinsic motivation in exercise and the relationship with exercise enjoyment. *Journal of Applied Biobehavioral Research, 10*, 113-132.

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Table 1. Musical Selections Used in the Experiment

Selection Details	Artists		
	The Stereophonics	Christina Aguilera	Michael Jackson
Track 1 Title (80 bpm)	Caravan Holiday (Jones, 2001, track 11)	Beautiful (Perry, 2002, track 11)	Keep The Faith (Ballard, 2001, track 12)
Track 2 Title (120 bpm)	Half The Lies You Tell Ain't True (Jones, 1999, track 6)	Fighter (Remix) (Aguilera & Storch, 2003, track 1)	Thriller (Temperton, 2003, track 5)
Track 3 Title (140 bpm)	Last Of The Big Time Drinkers (Jones, 1997, track 9)	Beautiful (dance remix) (Perry, 2002, track 1)	Beat It (Jackson, 2003, track 4)

Table 2. Descriptive Statistics and Three-Way ANOVA for Music Tempo Preference Across Three Exercise Intensities and Between Genders

Independent Variables	Tempo	*M*	*SD*	Std. Skew.	Std. Kurt.
40% maxHRR					
Women	Slow	4.86	1.46	1.06	0.34
	Medium	6.71	0.91	-0.07	-0.57
	Fast	6.71	1.44	-0.54	-0.58
Men	Slow	4.20	1.66	1.62	0.86
	Medium	7.13	1.19	2.04*	1.03
	Fast	7.13	1.64	0.42	0.22
Women and Men	Slow	4.52	1.57	1.49	0.22
	Medium	6.93	1.07	2.08*	1.49
	Fast	6.93	1.53	-0.45	-0.57
60% maxHRR					
Women	Slow	4.93	1.27	0.63	-0.63
	Medium	7.36	0.74	-1.22	-0.55
	Fast	7.21	1.12	-0.18	0.13
Men	Slow	4.27	1.10	-1.05	-0.33
	Medium	7.13	0.92	1.72	0.80
	Fast	7.00	1.65	-0.95	-1.10
Women and Men	Slow	4.59	1.21	-0.65	-0.61
	Medium	7.24	0.83	0.71	-0.25
	Fast	7.10	1.40	-1.23	-0.74
75% maxHRR					
Women	Slow	4.64	1.01	-0.32	-0.71
	Medium	6.43	1.28	-2.04*	2.80**
	Fast	7.43	1.02	-1.77	1.24
Men	Slow	4.20	1.47	0.15	-0.32
	Medium	6.47	1.46	-1.66	0.57
	Fast	7.33	1.35	-1.57	1.24
Women and Men	Slow	4.41	1.27	-0.69	-0.21
	Medium	6.45	1.35	2.30*	1.33
	Fast	7.38	1.18	-2.21*	1.56

Table 2 continues

Table 2. continued

Independent Variables		*M*	*SD*	Std. Skew.	Std. Kurt.
Exercise Intensity	40% maxHRR	6.13	1.80	-0.89	0.85
	60% maxHRR	6.31	1.69	-1.78	-0.89
	75% maxHRR	6.10	1.77	-1.74	-1.03
Music Tempo	Slow	4.51	1.09	0.79	-0.45
	Medium	6.87	0.77	1.12	0.76
	Fast	7.14	1.03	-0.69	-0.58
Gender	Women	6.25	1.30	-2.21*	0.20
	Men	6.10	1.73	-0.70	-1.32
Interaction Effects					
Exercise Intensity x Music Tempo x Gender:			$F(4,108) = .38, p > .05, \eta^2 = .01$		
Exercise Intensity x Music Tempo:			$F(4,108) = 2.79, p < .05, \eta^2 = .09$		
Exercise Intensity x Gender:			$F(2,54) = .71, p > .05, \eta^2 = .03$		
Music Tempo x Gender:			$F(2,54) = 1.59, p > .05, \eta^2 = .06$		
Main Effects					
Exercise Intensity:			$F(2,54) = .96, p > .05, \eta^2 = .03$		
Music Tempo:			$F(2,54) = 95.40, p < .05, \eta^2 = .78$		
Gender:			$F(1,27) = .34, p > .05, \eta^2 = .01$		

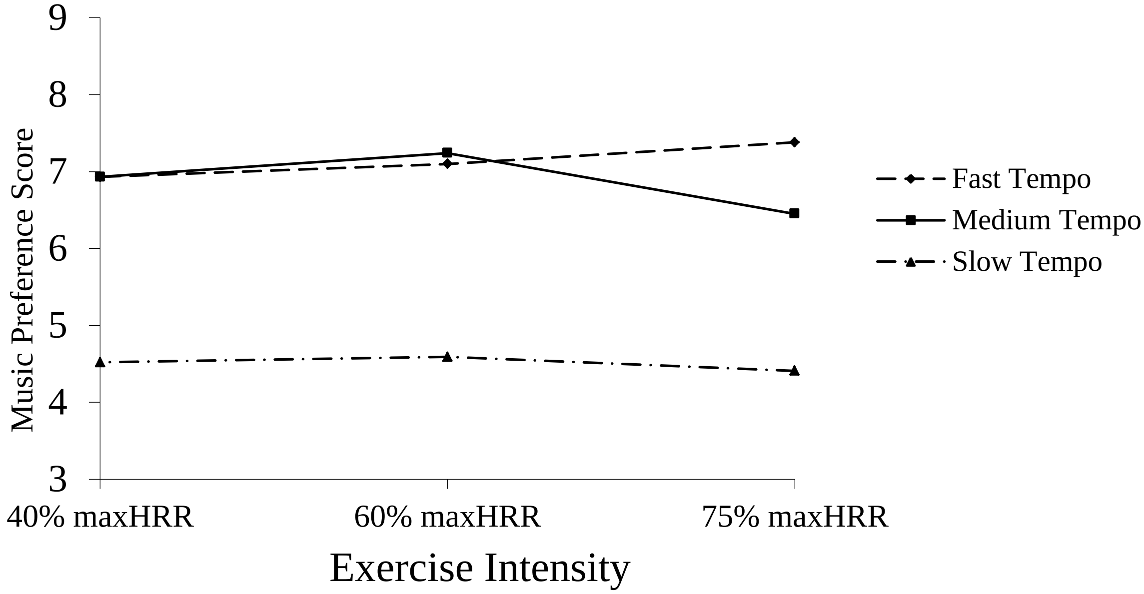
Note. *M* = mean; *SD* = standard deviation; maxHRR = maximal heart rate reserve; all η^2's included are partial η^2's. Std. Skew. = Standard Skewness. Std. Kurt = Standard Kurtosis.

* $p < .05$.

** $p < .01$.

Figure Captions

Figure 1. Significant two-way interaction for Exercise Intensity x Music Tempo; $p < .05$.


9
8
7
6
5
4
3
Music Preference Score
40% maxHRR
60% maxHRR
75% maxHRR
Exercise Intensity
Fast Tempo
Medium Tempo
Slow Tempo