

1 Running Head: Heart rate and music tempo

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3 Karageorghis, C. I., Jones, L., & Low, D. C. (2006). Relationship between exercise heart rate and
4 music tempo preference. *Research Quarterly for Exercise and Sport*, 77, 240-250.

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8 Relationship Between Exercise Heart Rate and Music Tempo Preference

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16 Second revision submitted: 8 July 2005

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Abstract

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

19 Key words: music speed, rhythm response, treadmill walking

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Relationship Between Exercise Heart Rate and Music Tempo Preference

1 The use of music in sport and exercise contexts has attracted considerable interest from
2 researchers in recent years (e.g., Karageorghis, Terry, & Lane, 1999; Szabo, Small, & Leigh,
3 1999; Tenenbaum, Lidor, Lavyan, et al., 2004) and it has long been considered an effective
4 means by which to enhance the exercise experience (see Karageorghis & Terry, 1997, for a
5 review). Poorly designed studies and lack of an underlying theoretical framework blighted much
6 of the early research work in this area. These problems were addressed in part by Karageorghis
7 and Terry (1997), who provided guidelines on study design, and Karageorghis et al. (1999), who
8 developed a conceptual framework for the assessment of the motivational qualities of music in
9 sport and exercise.
10

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

20 Tempo is considered to be the most significant determinant of musical response (Brown,
21 1979; Budd, 1985; Hevner, 1935; Karageorghis et al., 1999). Berlyne (1971) predicted a
22 curvilinear relationship between preference and tempo. A review by Bruner (1990) supported
23 this; however, the listener's physiological arousal and the context in which the music is heard

1 may affect the tempo preference (North & Hargreaves, 1997), meaning that as physiological
2 arousal increases, one should, accordingly, prefer higher tempi. Neuropsychologists have asserted
3 that the optimal speed at which humans are able to process rhythmical stimuli may influence
4 preferred tempo (Carroll-Phelan & Hampson, 1996). Fast tempi and strong rhythms may
5 contribute to preference, because they are inherently stimulative (Gaston, 1951). Therefore,
6 Berlyne's (1971) proposal, that the arousal potential of stimuli determines preference, appears
7 intuitively appealing. The implication is that during physical activity there will be stronger
8 preferences for fast tempo music, owing to increases in physiological arousal.

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

16 Iwanaga's (1995a, 1995b) work was criticized by LeBlanc (1995), who argued that the
17 methodologies were unrepresentative of those used in traditional music research and generally
18 lacking in external validity. Specifically, in normal circumstances, listeners are seldom able to
19 alter the tempo of a piece of music to which they are listening. Rather, most judgments of tempo
20 preference are made post hoc. Traditional music research (e.g., LeBlanc, Colman, McCrary,
21 Sherrill, & Mallin, 1988; LeBlanc & McCrary, 1983) indicates that listeners generally prefer
22 faster tempi than heart rates for people at rest or performing normal activity. Further, research
23 consistently shows that the younger participants are the faster their preferred tempi (LeBlanc,
24 1982; LeBlanc et al., 1988). LeBlanc (1995) suggested that Iwanaga's findings could be validated

1 through having the same group of participants select their preferred tempi at different work
2 intensities. If the same participants preferred tempi close to their heart rates in a range of
3 conditions at different work intensities, it would offer strong support for Iwanaga's hypothesis
4 and subsequent findings.

5 Using a questionnaire approach, research (Karageorghis, Terry, & Lane, 1999; Priest,
6 Karageorghis, & Sharp, 2004), has shown that women exhibit a stronger preference than men for
7 the rhythmical qualities of music. It is, therefore, plausible that, owing to their greater exposure to
8 dance and movement-to-music during their formative years (see Pellett, 1994), women will show
9 a more marked preference for music with a tempo that is linked to their exercise intensity. It is
10 also plausible that this preference is reinforced in later life through attendance of exercise-to-
11 music classes. Hence, the purpose of the present study was to extend the work of Iwanaga
12 (1995a, 1995b) to examine the relationship between exercise intensity and music tempo
13 preference using three work intensities (40%, 60% and 75% of maximal heart rate reserve:
14 maxHRR) and music at 80, 120 and 140 beats per minute (bpm) between genders. Such work is
15 valuable insofar as knowing how the impact of exercise intensity impacts on music preference
16 will allow practitioners to tap the ergogenic and psychophysical effects of music with greater
17 precision.

18 It was hypothesized that, in accordance with previous findings (Iwanaga, 1995a, 1995b),
19 there would be a positive linear relationship between exercise intensity and music tempo
20 preference, with women exhibiting a more pronounced response to changes in music tempo.
21 More specifically, through an interaction approach, it was predicted that: (a) preference for slow
22 tempo music would be highest at 40% maxHRR and lowest at 75% maxHRR; (b) preference for
23 medium tempo music would be highest at 60% maxHRR and lowest at 40% maxHRR and 75%
24 maxHRR; and (c) preference for fast tempo music would be lowest at 40% maxHRR and highest

1 at 75% maxHRR. It was also hypothesized that, because young adults were tested, the preference
2 ratings for slow tempo music would be significantly lower than preferences for both medium and
3 fast tempo music at all exercise intensities.

4 Method

5 *Stage 1: Music Selection*

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

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

1 A panel of six undergraduate sports science students (3 women and 3 men, M age = 20.8
2 years, $SD = 0.4$ years) rated 27 tracks using the BMRI. This panel also matched the profile of the
3 intended pool of experimental participants in terms of age and sociocultural background.
4 Specifically, they rated the motivational qualities of each track with reference to a treadmill-
5 walking task according to the instructions of Karageorghis et al. (1999). Tracks that had similar
6 motivational quotients at each of the three required tempi (80, 120 and 140 bpm) were recorded
7 onto CDs in counterbalanced order. Therefore, nine CDs were created (three artists x three
8 tempi), each containing three tracks from one of the three selected artists. The tracks from each
9 artist were also recorded in counterbalanced order. Copyright permission was requested from the
10 music publishers to record the tracks for research purposes, and full details are presented in Table
11 1.

12 *Stage 2: Experimental Investigation*

13 Power Analysis. A power analysis was conducted to establish appropriate sample size.
14 With alpha set at .05 and power at .8 to protect beta at four times the level of alpha (Cohen,
15 1988), based on an estimated moderate effect size (partial $\eta^2 = 0.08$) for the exercise intensity x
16 music tempo preference interaction (cf. Iwanaga, 1995b), it was calculated that approximately 28
17 participants would be required. There were no experimental data to inform the expected effect
18 size for the gender difference explored in the present analysis.

19 *Participants.* Twenty-nine volunteer participants comprising 14 women (M age = 20.4
20 years, $SD = 1.3$ years) and 15 men (M age 20.3 years, $SD = 1.1$ years) were selected from the
21 body of sports science undergraduates at Brunel University. All were Caucasians brought up in
22 the United Kingdom. The research team strove to ensure that participants were homogeneous in
23 terms of their age and sociocultural background, as these are deemed to be key factors that impact
24 upon reactivity to music (Karageorghis & Terry, 1997; Lucaccini & Kreit, 1972). Participants

1 were drawn from outfield positions in weight-bearing sports (e.g., rugby union, soccer, netball,
2 field hockey, etc.) to maintain some homogeneity in terms of their aerobic fitness and suitability
3 for treadmill walking. An inducement was used to recruit participants. Specifically, their names
4 were entered into a draw for an item of sports apparel, with separate draws conducted for women
5 and men.

6 *Apparatus and Measures.* A treadmill (Powerjog GXC200) was used for testing along
7 with a CD player (Philips AZ2555, Philips Electronics, Cambridge, UK) and a decibel meter (GA
8 102 Sound Level Meter Type 1; Castle Associates, Scarborough, UK) to standardize music
9 intensity. Target heart rate was assessed by use of a heart rate monitor (Polar Accurex Plus;
10 Polar, Kempele, Finland) and a sensor held by the experimenter. Music preference at each of the
11 three work intensities was assessed using a single item: “Rate your preference for this track based
12 on your current work level” with responses provided on a 10-point scale anchored by 1 (“I do not
13 like it at all”) and 10 (“I like it very much”).

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

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

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

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

22 *Experimental Trial.* Three experimental conditions scheduled for each participant over
23 consecutive weeks. Conditions comprised of walking at 40%, 60%, and 75% maxHRR.

24 Participants were required to follow identical patterns of activity and diet with no other vigorous

1 physical activity permitted prior to the trial on each test days. Further, they were not permitted to
2 eat a meal within two hours prior to testing. The order of conditions was randomized for each
3 participant, and they engaged in the experiment individually.

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

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

21 All musical selections included one verse and one chorus and were approximately 1.5 min
22 in duration. Further, when tracks deviated slightly from the required tempi, they were digitally
23 altered during recording to correspond with the required tempo. Any alterations were so small as
24 to not be discernible. Ten seconds before the end of each track, participants were asked to rate

1 their preference for the piece of music based on their current work level. The order of track
2 presentation was randomized to avoid response bias. In between each track, a technique known as
3 a “filler” (Bargh & Chartrand, 2000) was employed to facilitate active attentional manipulation
4 so that the impact of one track would not carry over to the next and present a threat to internal
5 validity. The filler comprised a mental arithmetic task that required participants to recite either
6 the 9 or 12 times table backwards. Participants were informed that no penalties would be incurred
7 for poor performance on this task. The entire procedure was repeated until the three tracks from
8 the same artist were rated. The same artist(s) was/were used for the subsequent two trials, which
9 were administered on different days. Participants performed a 2-min warm down at the end of
10 each trial. The total time each participant on the treadmill during each experimental trial was
11 approximately 12 min.

12 *Data Analysis*

13 Data were screened for univariate outliers using z scores $> \pm 3.29$ and then for
14 multivariate outliers using the Mahalanobis distance method with $p < .001$ (Tabachnick & Fidell,
15 2001). There was a single dependent variable—music preference—and three independent
16 variables: exercise intensity (40%, 60%, and 75% maxHRR), music tempo (slow, medium, and
17 fast), and gender. Thus, following checks to ensure the data were suitable for parametric analysis,
18 a mixed-model 3 x 3 x 2 (Exercise Intensity x Music Tempo x Gender) analysis of variance was
19 applied.

20 Results

21 Checks for outliers revealed no univariate or multivariate outliers. Tests of the
22 distributional properties of the data in each analysis cell revealed minor violations of normality in
23 7 of the 35 cells (all at $p < .05$; see Table 2): At 40% maxHRR, the preference scores of men
24 responding to medium tempo exhibited significant positive skewness; at 40% maxHRR, the

1 combined scores of women and men responding to medium tempo music exhibited significant
2 positive skewness; at 75% maxHRR, the preference scores of women responding to medium
3 tempo exhibited significant negative skewness and positive kurtosis; at 75% maxHRR, the
4 combined scores of women and men responding to medium tempo music exhibited significant
5 positive skewness; and at 75% maxHRR, the combined scores of women and men responding to
6 fast tempo music exhibited significant negative skewness. Also, women exhibited significant
7 negative skewness in their music preference scores independent of exercise intensity and music
8 tempo. Keppel (1991) indicated that ANOVA is sufficiently robust to withstand such minor
9 violations of normality, and thus, a decision was taken not to apply logarithmic transformation.
10 Mauchly's test of sphericity was non-significant, Mauchly's $W = .59, p > .05$. Collectively, the
11 diagnostic tests indicated that the assumptions underlying a three-way mixed-model ANOVA
12 were satisfactorily met and that the results would be generalizable to the population of
13 participants.

14 *Interaction Effects*

15 The higher-order interaction of Exercise Intensity x Music Tempo x Gender was non
16 significant ($p > .05$) as were the two-way interactions of Exercise Intensity x Gender and Music
17 Tempo x Gender (see Table 2). However, as expected, there was a significant two-way
18 interaction for Exercise Intensity x Music Tempo (see Table 2 and Figure 1), $F(4,108) = 2.79, p <$
19 $.05$, which yielded a moderate effect size (partial $\eta^2 = .09$). More specifically, follow-up within-
20 subjects contrasts, $F(1,27) = 12.60, p < .01$, indicated that the preferences for medium vs. fast
21 tempo music differed significantly at 75% maxHRR, with a decrease in preference for medium
22 tempo music when compared against fast tempo, and the medium tempo music at 60% maxHRR
23 (partial $\eta^2 = .32$).

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

7 *Main Effects*

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

14 Discussion

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

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

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

6 *Exercise Intensity and Music Tempo Preference*

7 A strength of the present study was that an attempt was made to standardize the potential
8 impact of the music in all aspects other than tempo. Thus, tracks from the same artist were used
9 and these tracks were similar in terms of their motivational qualities, as rated using the BMRI.
10 Music was selected with reference to the sub-culture/age-group preferences of the experimental
11 participants in line with previous recommendations (Karageorghis & Terry, 1997). Also raising
12 the gradient of the treadmill to increase exercise intensity, rather than increasing its velocity,
13 controlled for the commonly observed phenomenon of synchronization (Anshel & Marisi, 1978;
14 Mertesdorf, 1994). In support of the conceptual model Karageorghis et al. (1999) and the
15 suggestions of several other authors (Brown, 1979; Budd, 1985; Hevner, 1935; North &
16 Hargreaves, 1997), tempo appeared to have a profound influence on music preference, regardless
17 of exercise intensity. This provides empirical support for the notion that, during exercise, higher
18 tempi are preferred to slower tempi. This observation can be attributed to at least one of three
19 underlying mechanisms. First, higher tempo music is preferred during exercise, because it reflects
20 participants' the physiological arousal level (Berlyne, 1971; North & Hargreaves, 1997). Second,
21 young adults prefer higher tempo music regardless of their physiological arousal level (Gfeller,
22 1988; LeBlanc, 1982; LeBlanc et al., 1988; Priest et al., 2004). Third, people are conditioned to
23 respond positively to fast tempo music during exercise owing to its ubiquity in such
24 environments (North & Hargreaves, 1997).

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

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

1 Results supported the hypothesis that there would be a significantly greater preference for
2 medium and fast tempo music compared to slow music, but there were no differences for slow
3 tempo between the three exercise intensities. This was part of the interaction effect expected to
4 emerge. The present data suggest that slow music is inappropriate for repetitive exercise,
5 irrespective of exercise intensity. Further, the lack of an interaction indicates that slow tempo
6 music was universally least preferred (M preference = 4.51, SD = 1.09) and that this preference
7 did not vary with exercise heart rate. The implication of this finding is that medium and fast
8 tempo music should be played in British gymnasias, particularly where the majority user group
9 comprises of Caucasian young adults. However, practitioners should be mindful of the fact that
10 when working with individual clients, a switch from slow to fast tempo music may engender an
11 ergogenic effect (see Szabo et al., 1999). There is scope for further research into preference for
12 tempo variation of asynchronous music. From recent literature, a clear picture is emerging with
13 regard to the impact of individual components of music such as tempo and style (Priest et al.,
14 2004), but we do not yet have a strong empirical basis for the structure of an entire music
15 program in exercise.

16 Other recommendations that emanating from the present findings concern how music
17 tempo might impact upon aspects of exercise behavior, most notably initiation and adherence.
18 First, given that the arousal potential of stimuli determines preference (Berlyne, 1971), and that
19 individuals often require a moderate increase in arousal to initiate physical activity (Oxendine,
20 1984), it follows logically that listening to music of a medium tempo prior to exercise will assist
21 participants in attaining an optimal mindset. Moreover, if such music contains lyrical affirmations
22 pertaining to aspects of motivation (e.g., “work your body” or “search for the hero inside
23 yourself”), it will have an even more potent effect (Karageorghis & Terry, 1997; Karageorghis et
24 al., 1999; Priest et al., 2004). Second, given the burgeoning evidence surrounding the impact of

1 in-task affect and enjoyment on adherence (e.g., Motl, Dishman, Saunders, Dowda, Felton, &
2 Pate, 2001; Sallis, Prochaska, Taylor, Hill, & Geraci, 1999; Vlachopoulos & Karageorghis,
3 2005), musical accompaniment that induces positive affect and promotes enjoyment is likely to
4 increase levels of adherence.

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

16 *The Moderating Effect of Gender*

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

23 A limitation of the present study is that even though tempo was tightly controlled, it was
24 difficult to standardize *accentuation* in the music across exercise intensities (i.e., the other

1 element impacting upon a rhythm response), which concerns the periodic organization of sound.
2 The upshot of this is that although women may be more sensitive to the rhythmical qualities of
3 music, they may well be more attuned to the accentuation aspect of rhythm. Although tempo
4 determines how fast one might dance, or one's speed of movement in an aerobic dance exercise
5 class, it does not determine the *pattern* of movement; this is determined by accentuation.

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

13 *Conclusions and Recommendations*

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

23 Collectively, the present findings indicate that at exercise intensities up to 60% maxHRR,
24 participants prefer music in the range 120–140 bpm. At 75% maxHRR, fast tempo music (140

1 bpm) is preferred, while even at a low exercise intensity, slow music appears to be an
2 inappropriate accompaniment for motoric, rhythmical, and repetitive exercise. There was a
3 moderate positive relationship between exercise intensity and music tempo preference (partial η^2
4 = .09). Exercise practitioners need to be cognizant of the fact that slow tempo music may reduce
5 the quality of the exercise experience, while fast tempo music should be the primary choice for
6 high intensity exercise, particularly with British Caucasian young adults. Beyond this, it is also
7 important to select music with reference to the idiomatic preferences and socio-cultural
8 background of exercise participants (Karageorghis & Terry, 1997; Lucaccini & Kreit, 1972).

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

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

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

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10

1 **Table 1.** Musical Selections Used in the Experiment

2

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)

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

3

4

Independent Variables	Tempo	<i>M</i>	<i>SD</i>	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

1 Table 2. continued
2

Independent Variables		<i>M</i>	<i>SD</i>	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.

* $p < .05$.

** $p < .01$.

1 Figure Captions

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

3

