Psychological Effects of Music Tempi during Exercise

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Psychological Effects of Music Tempi during Exercise

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Key words
- asynchronous music
- motor rhythm
- physical activity
- rhythm response
- tempo

Abstract

The purpose of this study was to investigate the effects of music tempi on music preference, intrinsic motivation, and flow during long-duration exercise (~ 26 min). Subjects (n = 29) selected the music of a single artist then walked at 70% of maximum heart rate reserve (maxHRR) on a treadmill under three experimental conditions (medium tempi, fast tempi, and mixed tempi) and a no-music control. A music preference item, the Intrinsic Motivation Inventory, and Flow State Scale-2 were completed after each trial. Data were analyzed using a mixed-model (Gender × Condition) ANOVA and MANOVA. The Gender × Condition interaction was nonsignificant in both analyses ($p > 0.05$). Contrary to expectations, higher preference scores were recorded for medium tempi than for mixed tempi (means: 7.8 ± 1.3 vs. 7.1 ± 1.1). The medium tempi music also yielded the highest levels of intrinsic motivation ($p < 0.001$). Pairwise comparisons showed that interest-enjoyment was higher for medium tempi when compared to mixed tempi, 95% CI = 1.80 – 8.48, $p = 0.001$, and that each of the music preference experimental conditions yielded higher scores than the no-music control. Also, pressure-tension was lower for medium tempi compared to fast tempi, 95% CI = – 3.44 – 0.19, $p = 0.022$, and for both medium and mixed tempi compared to control (95% CI = – 5.33 – 2.89, $p = 0.000$; 95% CI = – 4.24 – 0.64, $p = 0.004$). A main effect was found for global flow ($p = 0.000$) with the highest mean score evident in the medium tempi condition (14.6 ± 1.5). Follow-up comparisons indicated that the medium tempi condition yielded higher flow scores than the control, 95% CI = 1.25 – 3.60, $p = 0.000$, as did fast tempi, 95% CI = 0.89 – 3.14, $p = 0.000$, and mixed tempi, 95% CI = 1.36 – 3.76, $p = 0.000$. It was concluded that a medium tempi music program was the most appropriate for an exercise intensity of 70% maxHRR.

Introduction

Music has long been considered a motivational tool in the domain of sport and exercise [2, 20, 24]. Numerous studies have sought to measure the magnitude of its purported motivational effects (e.g., [11, 14, 21, 34]), and these have focussed primarily upon the impact of three types of music: *Pretest, synchronous*, and *asynchronous* music. The present study focuses on the effects of asynchronous music; this is music played in the background without any conscious effort from the subject to keep their movements in time with music tempo [38].

Terry and Karageorghis [38] presented a conceptual framework proposing four factors that contribute to the motivational qualities of music: *Rhythm response* relates to how people react to music rhythm – most notably tempo which is the speed of music as measured in beats per minute; *musicality* concerns the pitch-related elements of music such as harmony and melody; *cultural impact* has to do with the pervasiveness of music within society; and *association* pertains to extra-musical associations that a piece may conjure (e.g., Survivor's *Eye of the Tiger* and boxing). Tempo, an element of rhythm response, is considered the most significant factor in determining an individual's response to a piece of music [15, 34].

Berlyne [4] predicted a curvilinear relationship between preference and tempo wherein during normal daily activities (not exercise) people should generally report a preference for medium tempo music. Bruner [9] supported the notion that tempo is a key determinant of one's response to music; however, the listener's physiological arousal and the context in which they hear the

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music also impact upon tempo preference [27]. Moreover, it has been proposed that the arousal potential of stimuli determines preference, therefore, during exercise, there should be stronger preferences reported for fast tempo music owing to the associated increases in physiological arousal [4]. Indeed, fast music of a high intensity (loudness) appears to be the most appropriate accompaniment for vigorous exercise [13,29].

A body of work has examined the relationship between exercise heart rate and preference for music tempo [18,20]. Using a short-duration treadmill walking task, Karageorghis, Jones, and Low [18] found a significantly higher preference for fast tempo music (140 beats·min^{-1}) compared to medium tempo (120 beats·min^{-1}) and slow tempo (80 beats·min^{-1}) music at 75% of maximum heart rate reserve (maxHRR). Although slow tempo music was least preferred at all exercise intensities, there were no differences reported between medium and fast tempi at either 40% maxHRR or 60% maxHRR. The study did not assess preference during long-duration exercise and the authors suggested that continual exposure to high tempo music may result in negative motivational consequences such as boredom and irritation; moreover, that a mixed tempi condition might have a greater motivational effect than a single-tempo condition, as was indicated in previous research that employed a cycle ergometry task [35]. This suggestion was the genesis of the present study, which examined music preference, intrinsic motivation, and flow in response to fast tempi, medium tempi, and mixed tempi (medium-fast-fast-medium-fast-fast) music conditions during long-duration exercise.

Intrinsic motivation comes from within, is fully self-determined and characterized by interest in and enjoyment derived from an activity [32]. The Intrinsic Motivation Inventory (IMI) is one of the most valid and reliable instruments that has been used to measure intrinsic motivation [31]. High scores on interest-enjoyment and effort-importance subscales of the IMI are indicative of high levels of self-reported intrinsic motivation. Conversely, a low pressure-tension score signifies high intrinsic motivation; this is because pressure-tension is an antagonistic marker of intrinsic motivation. These were the three subscales deemed relevant for the present investigation.

Flow has been described as the total absorption into an activity, to the point where time appears to either speed up or slow down [12]. It entails an altered state of awareness in which one feels deeply involved in the task at hand and where body and mind operate harmoniously. Flow is an optimal psychological state that is deeply enjoyable and a great source of motivation for those engaged in any form of physical activity [16]. Consequently, flow is a highly sought-after state. It has, in fact, been described as the "apotheosis of intrinsic motivation" [28]. Ostensibly, in a state of flow, an activity is enjoyable in its own right and not pursued for the derivation of external rewards or benefits. Accordingly, it is expected that an appropriate music program should impact on intrinsic motivation and flow in a similar manner. The results of past work indicate that appropriate music selections can have a positive impact on the experience of flow [28].

It was hypothesized that the mixed tempi music condition would elicit significantly higher music preference scores, intrinsic motivation, and global flow when compared to the other conditions. Also, the fast tempi condition would elicit the second highest scores and would exceed the medium tempi condition. Finally, all three music tempi conditions were expected to yield higher scores on all dependent variables when compared to a no-music control condition.

Materials and Methods

Stage 1: music selection

Following procurement of ethical approval and written informed consent for both stages of the study, 118 undergraduates (mean age 20.2 ± 1.4 years) who were Caucasian and brought up in Great Britain, were surveyed to establish their three favorite music artists for an exercise context. These students matched the profile of the intended pool of experimental subjects both in terms of age and sociocultural background [20]. Following the survey, the three highest-rated artists representing the women's favorite (*Basement Jaxx*), men's favorite (*The Prodigy*), and the favorite across genders (*Queen*) were used.

Nine tracks at medium tempi (115 – 120 beats·min^{-1}) and nine tracks at fast tempi (140 – 145 beats·min^{-1}) from each artist were rated by a panel of eight subjects who regularly exercised to music. Earlier work had shown that differences between these two tempi ranges were discernible during high-intensity exercise (75% maxHRR) and resulted in meaningful differences in music preference [18]. The rating was conducted using the Brunel Music Rating Inventory-2 [19] to standardize the motivational qualities of the tracks. The "tempo" item was omitted as tempo constituted an independent variable in the present design. This procedure was intended to ensure that, although the tempi between tracks for each artist differed, there would be homogeneity in the motivational qualities of the music so that this would not threaten internal validity. A total of 21 tracks from the three artists were discarded as a consequence.

In the preparation of music selections for the experimental trials, 11 tracks were recorded for *Basement Jaxx* (five medium and six fast tempi), 10 tracks for *The Prodigy* (five medium and five fast tempi), and 12 tracks for *Queen* (six medium and six fast tempi). These tracks, which had similar motivational quotients at each of the two tempi, were recorded onto CDs with permission from the record companies. A different number of tracks were recorded from each artist to ensure that the music programs were of equal duration.

Stage 2: experimental investigation

Subjects

Following a power analysis based on a moderate effect size (η_p^2 = .09) [18], 29 volunteer subjects comprising 14 women (mean age 20.7 ± 1.1 years) and 15 men (mean age 20.4 ± 1.4 years) were selected from the student body at Brunel University, West London. Subjects were Caucasians brought up in the United Kingdom. They were homogeneous in terms of their age and sociocultural background, as these have been identified as factors that impact upon reactivity to music [20,24]. Also, subjects were drawn from outfield positions in weight-bearing sports (e.g., field hockey, netball, rugby union, soccer, etc.). This maintained some homogeneity in terms of their cardiovascular fitness and appropriateness for the experimental task of treadmill walking. An inducement of a prize draw was used to recruit subjects, with separate draws conducted for women and men.

Apparatus and measures

A treadmill (Powerjog GXC200; Powerjog, Brigend, UK) was used for testing along with a wall-mounted stereo system (Tascam

CD-A500; Tascam, Tokyo, Japan) and a decibel meter (GA 102 Sound Level Meter Type 1; Castle Associates, Scarborough, UK) to standardize music intensity. Target heart rate was assessed using 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 the musical selections you have heard based on the work level you have just experienced" with responses provided on a 10-point scale anchored by 1 ("not liked at all") and 10 ("liked very much"). To facilitate comparison with previous findings, this item was drawn from Karageorghis et al. [18] to tap the suitability of the music for the work intensity of 70% maxHRR, and appropriate explication was provided to subjects if required.

Intrinsic motivation for the treadmill walk was assessed using the IMI [31]. The IMI consists of seven subscales of which only three were deemed relevant for the present study: interest-enjoyment, pressure-tension, effort-importance. The IMI subscales have been shown to be factor-analytically coherent and stable across a variety of tasks, conditions, and settings. Items are rated on a seven-point Likert scale anchored by 1 ("strongly disagree") and 7 ("strongly agree"). McAuley et al. [25] reported acceptable internal consistency for all IMI subscales (e.g., interest-enjoyment $\alpha = .78$; pressure-tension $\alpha = .68$; effort-importance $\alpha = .84$).

Flow state was assessed by means of the FSS-2 [17], which is a 36-item inventory comprised of nine subscales. Subjects were asked to indicate the extent of their agreement with the items as representing their experience in the treadmill walking task they had just completed. Responses were provided on a five-point Likert scale anchored by 1 ("strongly disagree") and 5 ("strongly agree"). The FSS-2 is psychometrically superior to the original FSS and displayed a stable factor structure when tested across two independent samples. Internal consistency estimates ranged from .80 – .90. In the interests of parsimony, we used a *global flow score* representing the totality of the nine dimensions of flow.

Pretest and habituation trial

Subjects were required to walk on a treadmill at a speed that would induce an exercise intensity of 70% maxHRR. This was deemed to be an appropriate intensity to differentiate preference between varying musical tempi without requiring subjects to work at intensities involving significant anaerobic contribution to overall energy expenditure. It has been shown that music is relatively ineffective as a dissociation tool or ergogenic aid at high exercise intensities [3, 6]. To facilitate accurate assessment of subjects' maximal heart rate, they completed the Bruce protocol [8] and responded to an 11-point Ratings of Perceived Exertion (RPE) scale [5] each minute, beginning at the end of the first minute. Subjects were instructed to endure the task for as long as possible, and their maximal heart rate was recorded at the point of voluntary exhaustion using a heart rate monitor. Women endured for a mean of 12.04 min (± 1.38 min) while men endured for 13.38 min (± 1.39 min). The mean maximal heart rate achieved by women was 196.5 beats$\cdot$min^{-1} (± 4.3) and 196.9 beats$\cdot$min^{-1} (± 6.3) by men. In determining an appropriate working heart rate for each subject, heart rate reserve was accounted for through application of the Karvonen formula [22].

Subjects attended a habituation session at which the test protocol was explained and they were familiarized with the velocity at which they would be working during each test trial. The treadmill gradient was altered to obtain the desired exercise intensity rather than its velocity, which was set at 6 kph. The rationale for this was to control for any potential synchronization effect of stride rate with music tempo [2, 26, 34]. In earlier piloting of the protocol and previous published work [18], it was found that synchronization to music was not possible during treadmill walking because stride rate is determined by treadmill velocity. During treadmill running at low velocities, the opportunity does exist for the stride to either lengthen or shorten to facilitate some synchronous movement. Nonetheless, one's gait needs to be adjusted periodically, unless the treadmill belt is set to move in perfect synchrony with musical tempo.

Experimental trials

A repeated measures design was employed comprising three experimental conditions and one control condition. Trials were scheduled at the same time of day for each subject over a 4-week period. Conditions comprised treadmill walking at 70% maxHRR while subjects listened to medium tempi music (115 – 120 beats$\cdot$min^{-1}), fast tempi music (140 – 145 beats$\cdot$min^{-1}), mixed tempi music (a series of tracks arranged in the order medium-fast-fast-medium-fast-fast tempi), and a no-music control condition. Subjects were requested to follow identical patterns of activity and diet and not to engage in any other vigorous physical activity prior to the trial on each of the test days. Also, they were requested to refrain from eating a meal within 2 hours prior to a trial. The order of conditions to which subjects were exposed was randomized and they were administered each test individually.

At the first test session, subjects were given a choice of the three artists who were earlier rated by their peers as being the most popular: *Basement Jaxx, The Prodigy*, and *Queen*. While walking on the treadmill, subjects were instructed to look ahead at a large blank screen positioned in front of them. This was to negate the influence of any visual stimuli on their responses to the music. Music was played through wall-mounted speakers and the intensity standardized at 75 dB (ear level) using a decibel meter for each of the 33 tracks used. Based on previous research [1], this was deemed a safe level from an audiological perspective, as well as ensuring the music was sufficiently loud so as not to be obscured by the whir of the treadmill.

Subjects performed stretches followed by a 2-min warm-up on the treadmill at a velocity of 4.5 kph with no music and then at a constant velocity of 6 kph for each trial. The experimenter then took subjects to an exercise intensity corresponding with 70% maxHRR by raising the gradient of the treadmill until target heart rate was reached and maintained for a period of 1 min. Subjects selected the music of a single artist prior to their first experimental trial, and music of the same artist was used in each of the experimental trials. This was done to avoid the influence of different artists impacting upon subjects' responses to music. Indeed, previous research has indicated that the artist(s) can have a significant impact in determining music preference [7, 38].

In cases where tracks deviated slightly from the required tempi (115 – 120 beats$\cdot$min^{-1} and 140 – 145 beats$\cdot$min^{-1}), they were digitally altered during recording to correspond with the required tempo range; however, any such alterations were so small as not to be discernible. There were no major deviations in tempo within tracks other than in the track Bohemian Rhapsody by *Queen* for which the slow introduction and outro were edited out. The tempo preference item, three subscales of the IMI, and the FSS-2 were administered immediately after each trial. The tempo preference item was not administered in the control condition.

Data analysis

Data were screened for outliers and tested for the parametric assumptions underlying mixed-model ANOVA and MANOVA [36]. Specifically, the distributional properties of the data were examined in each cell of the analysis, Box's M test for homogeneity of variance-covariance matrices was computed, and Mauchly's test of sphericity was used to identify the need for Greenhouse-Geisser adjustment to F-tests. Music preference scores were assessed using a mixed-model 2 × 3 (Gender × Condition) ANOVA, while the IMI subscales and global flow score were assessed using a mixed-model 2 × 4 (Gender × Condition) MANOVA.

Results

Data screening revealed no outliers; however, tests of distributional properties indicated minor violations of normality in 17 of the 57 cells (30%; 13 at $p < 0.05$ and 4 at $p < 0.01$; **Table 1**). ANOVA and MANOVA are sufficiently robust to withstand such minor violations of normality [23]. In the mixed-model MANOVA, results of Box's M test indicated that the more conservative Pillai's Trace omnibus statistic should be used in preference to Wilks' lambda [36]. Collectively, the battery of diagnostic tests indicated that the assumptions underlying a two-way mixed-model ANOVA and MANOVA were satisfactorily met and that the results would be generalizable to the population of Caucasian British university students.

Interaction effects

The Gender × Condition interaction in the ANOVA was nonsignificant, $F2,_{1.54} = 0.30$, $p = 0.745$, $\eta_p^2 = .01$, as was the corresponding interaction in the MANOVA, Pillai's Trace = .55, $F12,_{16} = .99$, $p = 0.172$, $\eta_p^2 = .04$, (see **Table 1** and **Fig. 1**). The interaction effects indicated that gender did not moderate preference for music tempi or the motivation outcomes.

Main effects

The ANOVA results indicated that preference scores were higher in the medium tempi condition, $F2,_{54} = 3.29$, $p = 0.045$, $\eta_p^2 = .11$, when compared to the mixed tempi condition (**Table 1**); however, the associated pairwise comparison did not quite reach statistical significance, 95% CI = – 0.05 – 1.38, $p = 0.077$. The MANOVA indicated a main effect for all four dependent variables (**Table 1**; Pillai's Trace = .924, $F12,_{16} = 16.17$, $p = 0.000$, $\eta_p^2 = .92$): interest-enjoyment ($F3,_{81} = 48.70$, $p = 0.000$, $\eta_p^2 = .64$), pressure-tension ($F3,_{81} = 12.38$, $p = 0.000$, $\eta_p^2 = .31$), effort-importance ($F3,_{81} = 3.31$, $p = 0.024$, $\eta_p^2 = .11$) and global flow ($F1.852,_{49.996} = 25.79$, $p = 0.000$, $\eta_p^2 = .49$). Pairwise comparisons showed that interest-enjoyment was significantly higher for medium tempi when compared to mixed tempi, 95% CI = 1.80 – 8.48, $p = 0.001$, higher for medium tempi compared to control, 95% CI = 11.10 – 19.22, $p = 0.000$, higher for fast tempi compared to control, 95% CI = – 17.32 – 7.96, $p = 0.000$, and higher for mixed tempi compared to control, 95% CI = 6.57 – 13.49, $p = 0.000$. Further, pressure-tension was significantly lower for medium tempi compared to control, 95% CI = – 5.33 – – 2.09, $p = 0.000$, for medium tempi compared to fast tempi, 95% CI = – 3.44 – – 0.19, $p = 0.022$, and for mixed tempi compared to control, 95% CI = – 4.24 – – 0.64, $p = 0.004$. None of the pairwise comparisons for effort-importance approached statistical significance ($p < 0.05$) despite the significant main effect reported above. Global flow was significantly higher for medium tempi compared to control, 95% CI = 1.25 – 3.60, $p = 0.000$, for fast tempi compared to control, 95% CI = 0.89 – 3.14, $p = 0.000$, and mixed tempi compared to control, 95% CI = 1.36 – 3.76, $p = 0.000$.

Discussion

The results indicated that contrary to expectations, the medium tempi condition, rather than the mixed tempi and fast tempi conditions, elicited the highest levels of intrinsic motivation and flow. It was also the most preferred. More specifically, for interest-enjoyment, the medium tempo condition proved superior to all other conditions. There was a corresponding effect found for pressure-tension – an antagonistic marker of intrinsic motivation – insofar as it was lowest in the medium tempi condition. Also, global flow was highest in the medium tempi condition when compared to all other conditions. Similar to past work [18], gender did not moderate the impact of the music tempi on either the motivation variables or music preference.

The present results shed considerable light on participants' preferences and psychological responses to music of different tempi during a long-duration exercise task. They also serve to inform adaptations that may be employed in the methodologies used to examine such phenomena; detailed recommendations will be given later. The central finding is that using mixed tempi that were aligned with exercise intensity (70% maxHRR), and intended to relieve the boredom associated with listening to just one tempo, were not as effective as a singular music tempi condition (medium tempi at 115 – 120 beats · min^{-1}). Moreover, medium tempi were more effective than fast tempi (140 – 145 beats · min^{-1}) and this is surprising given that participants were working at a relatively high exercise intensity. In previous work [18], an interaction effect was found for Exercise Intensity × Music Tempo Preference which suggested that medium tempi selections were inappropriate for high intensity exercise (75% maxHRR) and that fast tempo selections yielded the most positive listening experience at this intensity.

We will interpret the results with reference to extant theory and related studies before considering how methodological limitations may also have accounted for the unexpected emergence of medium tempi as the most positive music condition. Higher tempi should be preferred during exercise owing to the notion that the arousal potential of stimuli determines preference. When physiological arousal is relatively high, there should be stronger preferences for faster tempi [4,27]. In addition, such tempi are *iconically representative* [33] of high energetic arousal. This means that they typically reflect the psychophysiological state of an individual engaged in a bout of exercise.

The work intensity in the present study (70% maxHRR) was not quite as high as that used by Karageorghis et al. [18] because the intention in the present study was for participants to endure the exercise task rather than reach a predetermined workload and then respond to a piece of music. Thus, there may be a step change in preference between 70% and 75% maxHRR in which participants express greater preference for fast tempi music. This is also the point at which they begin to rely more upon anaerobic energy production and become more acutely aware of physiological sensations [30]. In relation to this, although

Table 1 Descriptive statistics, ANOVA for preference scores, MANOVA for IMI subscale scores, and global flow

Independent variables	M	SD	Std. Skew	Std. Kurt
Medium tempi				
male				
▸ preference	7.6	1.4	– 1.64	1.74
▸ interest	32.3	5.5	1.95	2.10*
▸ pressure	8.5	2.7	0.52	– 1.07
▸ effort	22.5	3.4	– 2.02*	0.22
▸ flow	14.4	1.2	1.37	2.94**
female				
▸ preference	8.00	1.1	– 0.66	0.31
▸ interest	33.4	5.3	3.16**	2.46*
▸ pressure	10.3	3.3	1.94	1.04
▸ effort	22.0	5.9	– 0.75	0.30
▸ flow	14.9	1.8	– 1.62	– 0.34
males and females				
▸ preference	7.8	1.3	– 1.92	2.15*
▸ interest	32.9	5.3	0.66	2.72**
▸ pressure	9.3	3.1	2.05*	2.45*
▸ effort	22.2	4.7	– 1.54	1.15
▸ flow	14.6	1.5	1.06	0.23
Fast tempi				
male				
▸ preference	7.2	1.0	– 0.78	0.36
▸ interest	29.1	7.2	0.03	– 0.47
▸ pressure	9.5	3.0	0.12	– 0.54
▸ effort	20.5	5.8	0.49	– 0.65
▸ flow	14.5	1.5	2.43*	1.90
female				
▸ preference	7.5	1.2	0.87	0.18
▸ interest	31.6	5.5	1.21	0.49
▸ pressure	12.9	2.8	2.10*	0.70
▸ effort	23.1	4.4	0.65	– 0.74
▸ flow	14.0	1.3	1.98	1.90
males and females				
▸ preference	7.3	1.1	0.36	0.42
▸ interest	30.3	6.5	0.07	0.04
▸ pressure	11.1	3.3	0.60	0.61
▸ effort	21.8	5.2	0.20	0.78
▸ flow	14.3	1.4	2.99**	2.47*
Mixed tempi				
male				
▸ preference	7.1	0.9	0.61	– 0.43
▸ interest	28.1	5.8	1.26	– 0.15
▸ pressure	9.0	2.4	1.22	1.28
▸ effort	21.2	4.2	– 0.63	– 0.39
▸ flow	15.1	0.7	0.92	0.27
female				
▸ preference	7.1	1.3	0.32	– 0.87
▸ interest	27.4	4.0	0.31	0.50
▸ pressure	12.3	3.2	0.31	0.64
▸ effort	22.2	4.9	2.18*	2.19*
▸ flow	14.5	1.5	1.27	0.39
males and females				
▸ preference	7.1	1.1	0.55	– 0.82
▸ interest	27.8	4.9	1.57	0.16
▸ pressure	10.6	3.3	1.26	0.32
▸ effort	21.7	4.5	1.50	1.77
▸ flow	14.8	1.2	0.44	0.74
				cont.

Table 1 *continued*

Independent variables	M	SD	Std. Skew	Std. Kurt
No music control				
male				
▸ interest	17.9	6.6	1.14	– 0.69
▸ pressure	10.7	3.2	1.62	2.23*
▸ effort	18.9	4.5	0.26	– 0.92
▸ flow	12.5	2.2	1.60	0.86
female				
▸ interest	17.5	5.3	0.76	0.29
▸ pressure	15.5	3.4	1.22	0.69
▸ effort	19.8	3.5	0.33	0.36
▸ flow	11.9	1.6	0.78	0.61
males and females				
▸ interest	17.7	5.9	1.37	0.69
▸ pressure	13.0	4.1	1.07	0.24
▸ effort	19.3	4.0	0.14	– 0.92
▸ flow	12.2	1.9	2.09*	1.16
Interaction effects				
ANOVA	gender × condition	$F_{2,1.90} = 0.30$, $p = 0.745$, $\eta_p^2 = .01$		
MANOVA	gender × condition	Pillai's Trace = .55, $F_{12,16} = .99$, $p = 0.172$, $\eta_p^2 = .04$		
Main effects				
preference		$F_{2,54} = 3.29$, $p = 0.045$, $\eta_p^2 = .11$		
interest		$F_{3,81} = 48.70$, $p = 0.000$, $\eta_p^2 = .64$		
pressure		$F_{3,81} = 12.38$, $p = 0.000$, $\eta_p^2 = .31$		
effort		$F_{3,81} = 3.31$, $p = 0.024$, $\eta_p^2 = .11$		
flow		$F_{1.852,49.996} = 25.79$, $p = 0.000$, $\eta_p^2 = .49$		

* $p < 0.05$, ** $p < 0.01$

some research has shown that music is ineffective in moderating levels of perceived exertion at high intensities [3,37], it can impact positively on subjective ratings of affect [6,14].

It is entirely plausible that a preference for medium tempi music was reported owing to the phenomenon of *familiarity* [4,19,21]. More specifically, in everyday listening situations, exposure to medium tempi music is far more likely than exposure to fast tempi music. This has to do with the fact that moderately arousing music is preferred in everyday listening situations [4,14] and that most popular music is recorded at medium tempi rather than at slow and fast tempi. Owing to repeated exposure to medium tempi music, preference is increased and this, to a degree, may override the purported influence of physiological arousal [27].

Another plausible explanation for the present findings relates to self-determination theory and satisfaction of the needs underlying intrinsic motivation [32]. The mixed tempi and fast tempi conditions serve to "force the pace" a little and thus may undermine self-determination and flow given that in an experimental situation subjects will not wish to fatigue themselves excessively; particularly if involved in field sports. Hence, although subjects associated medium tempi with a "comfort zone", the higher tempi music conditions may have reduced their sense of autonomy during the exercise task.

A limitation in the present study and in previous exercise-related research [18] is that gradual increases in music tempi have not been examined in conjunction with gradual increases in exercise intensity; rather, categories of tempi (e.g., slow, medium, and fast) and predetermined exercise intensities have been used (e.g., 40%, 60%, and 75% maxHRR). This line of research could be

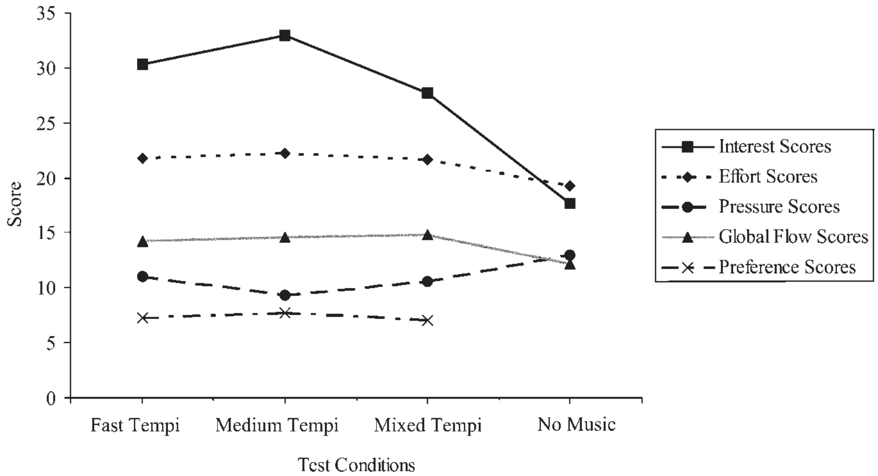

Fig. 1 Combined male and female mean scores for IMI subscales, global flow, and preference ratings.

developed through examining subtle increases in exercise intensity up to and beyond anaerobic threshold, while subjects listen and respond to music of a wide range of tempi.

Although the treadmill walking was performed asynchronously and the use of such an externally-paced task made it particularly difficult for synchronization to occur, there is a possibility that subjects attempted, perhaps subconsciously, to synchronize their movements with rhythmical aspects of the music [20,34]. Given that walking is a relatively slow tempo motor skill, the use of fast tempi musical selections may have resulted in some incongruence between the motor rhythm of the task and stimuli used; this is a limitation of the present study. Perhaps using a faster motor skill that required the same work intensity (e.g., cycle ergometry) may have yielded findings more in line with those predicted.

There were some further limitations in the study that may have had a bearing on the unexpected findings and should be considered by future researchers. First, in the mixed tempi condition, the drop from 140–145 beats·min^{-1} to 115–120 beats·min^{-1} for the duration of one track may have been a little too stark; a smoother mix with a lower tempo ~10 beats·min^{-1} below the fast tempi may have aided the aesthetic impact of the music program. Also, it is possible that the experimental task was not of sufficient duration for subjects to react substantially to the changes in tempo. There were only two changes from fast to medium tempi in the mixed tempi condition; however, an extension of the duration would have prevented some of the subjects from completing the task given that they were exercising at a relatively high intensity. A manipulation check could have been included; however, the researchers did not wish to sensitize subjects to the experimental manipulations. Finally, only a single music intensity was used, which was relatively high (75 dB). This does not inform how music intensity might impact upon preference and the motivation outcomes assessed in the present study.

Conclusions

For exercise bouts characterized by repetitive rhythmical movements such as walking, running or cycling up to 70% maxHRR, the evidence presented in the present study indicates that medium tempi music is likely to yield the best motivation outcomes and be most preferred. Also, up to 70% maxHRR, contrary to expectations, medium tempi music yields superior motivation outcomes to fast tempi music.

Future Directions

The present study warrants replication but with a more subtle manipulation of tempo in the mixed tempo condition and with use of a range of exercise tasks. The duration of exercise could also be extended in order that the tempo changes at least three times during each exercise bout. The likelihood of a point at which there is perhaps a step change in preference wherein fast music tempi are most likely to be preferred – somewhere between 70–75% maxHRR – is hinted at within the present findings combined with those of Karageorghis et al. [18], therefore this phenomenon warrants further investigation. An additional independent variable that should be considered by future researchers is music intensity given the known influence of this variable on affect, arousal, and motivation [10,13,29]. Finally, there is scope for additional examination of the relationship between music preference, music tempo, and self-determination given that preferred music, and tempi that match a particular motor rhythm, may facilitate a greater sense of autonomy [32].

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