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Effects of Music Tempi on Music Preference, Intrinsic Motivation, and Flow
during Long-duration Exercise ~~Psychological Effects of Music Tempi during Exercise~~

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Running head: Music Tempi and Preferences

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Abstract

This study investigated the effects of music tempi on intrinsic motivation, flow, and music tempo preference 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 tempo preference item, the Intrinsic Motivation Inventory, and Flow State Scale-2 and a tempo preference item were completed after each trial. Data were analyzed using a mixed-model (Gender x Condition) ANOVA and MANOVA. The Gender x Condition interaction was non-significant in both analyses. Contrary to expectations pertaining to the efficacy of mixed tempi music, the medium tempi music was actually more preferred than this condition. The main effect indicated that the medium tempi also music yielded the highest intrinsic motivation. A main effect was found for global flow, with follow-up comparisons indicating that the medium tempi condition yielded higher scores than the mixed and fast tempi conditions, and that experimental conditions yielded higher flow than the no-music control. There were significant differences for tempo preference with pairwise comparisons indicating that medium tempi was more preferred than the mixed tempi condition music (95% CI = -.05 – 1.38, $p < 0.05$). It was concluded that a medium tempo-tempi music program was the most appropriate for an exercise intensity of 70% maxHRR.

Key words

Asynchronous music · physical activity · rhythm response · tempo · aerobic exercise

40 Music has long been considered a motivational tool in the domain of sport and exercise [2,
41 ~~24~~20,24]. Numerous studies have sought to measure the magnitude of its purported
42 motivational effects [e.g. 11,14,~~20~~21,3334], and these have focussed primarily upon the
43 impact of three types of music: *Pre-test*, *synchronous*, and *asynchronous* music. The present
44 study focuses on the effects of asynchronous music; this is music played in the background
45 without any conscious effort from the subject to keep their movements in time with music
46 tempo [3738].

47
48 Terry and Karageorghis [3738] presented a conceptual framework proposing four factors that
49 contribute to the motivational qualities of music: *Rhythm response* relates to how people react
50 to music rhythm – most notably tempo which is the speed of music as measured in beats per
51 minute; *musicality* concerns the pitch-related elements of music such as harmony and melody;
52 *cultural impact* has to do with the pervasiveness of music within society, and *association*
53 pertains to extra-musical associations that a piece may conjure (e.g. Survivor's *Eye of the*
54 *Tiger* and boxing). Tempo, an element of rhythm response, is considered the most significant
55 factor in determining an individual's response to a piece of music [15,3334].

56
57 Berlyne (1971)[4] predicted a curvilinear relationship between preference and tempo wherein
58 during normal daily activities (not exercise), people should generally report a preference for
59 medium tempo music. Bruner's (1990)[9] review supported the notion that tempo is a key
60 determinant of one's response to music; however the listener's physiological arousal and the
61 context in which they hear the music also impact upon tempo preference [27]. Moreover, The
62 upshot of this is that as physiological arousal increases, one should accordingly report a
63 preference for higher music tempi. it has been proposed that the arousal potential of stimuli
64 determines preference therefore during exercise, there should be stronger preferences reported

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65 for fast tempo music owing to the associated increases in physiological arousal [4]. Indeed,
 66 fast music of a high intensity (loudness) appears to be the most appropriate accompaniment
 67 for vigorous exercise [13,29].

69 **Exercise heart rate and music tempo preference**

70 A body of work has examined the relationship between exercise heart rate and preference for
 71 music tempo [18,2420]. Using a short-duration treadmill-walking task, Karageorghis, Jones,
 72 and Low (~~2006~~)[18] found a significantly higher preference for fast tempo music (140
 73 ~~beats.min⁻¹.bpm~~) compared to medium tempo (120 ~~beats.min⁻¹.bpm~~) and slow tempo (80
 74 ~~beats.min⁻¹.bpm~~) music at 75% of maximum heart rate reserve (maxHRR). Although slow
 75 tempo music was least preferred at all exercise intensities, there were no differences reported
 76 between medium and fast tempi at either 40% maxHRR ~~and-or~~ 60% maxHRR. The study did
 77 not assess preference during long-duration exercise and the authors suggested that continual
 78 exposure to high tempo music may result in negative motivational consequences such as
 79 boredom and irritation; moreover, that a mixed tempi condition might have a greater
 80 motivational effect than a single-tempo condition, as was ~~demonstrated~~indicated in previous
 81 research that employed a cycle ergometry task [3435]. This suggestion was the genesis of the
 82 present study, which examined music preference, intrinsic motivation, and flow ~~and music~~
 83 ~~preference~~ in response to fast tempi, medium tempi, and mixed tempi (medium-fast-fast-
 84 medium-fast-fast) music conditions during long-duration exercise.

86 **Intrinsic motivation**

87 Intrinsic motivation comes from within, is fully self-determined and characterized by interest
 88 in and enjoyment derived from an activity [32]. One of the most valid and reliable instruments
 89 that has been used to measure intrinsic motivation is the Intrinsic Motivation Inventory (IMI)

90 [31]. High scores on interest-enjoyment and effort-importance subscales of the IMI are
 91 indicative of high levels of self-reported intrinsic motivation. Conversely, a low pressure-
 92 tension score signifies high intrinsic motivation; this is because pressure-tension is an
 93 antagonistic marker of intrinsic motivation. These were the three subscales deemed relevant
 94 for the present investigation.

95

96

97 **Flow state**

98 Flow has been described as the total absorption into an activity, to the point where time
 99 appears to either speed up or slow down [12]. It entails an altered state of awareness in which
 100 one feels deeply involved in the task at hand and where body and mind operate harmoniously.
 101 Flow is an optimal psychological state that is deeply enjoyable and a great source of
 102 motivation for those engaged in any form of physical activity [47][6]. Consequently, flow is a
 103 highly sought-after state. It has, in fact, been described as the “apotheosis of intrinsic
 104 motivation” [28]. Ostensibly, in a state of flow, an activity is enjoyable in its own right and
 105 not pursued for the derivation of external rewards or benefits. Accordingly, it is expected that
 106 an appropriate music programme should impact on intrinsic motivation and flow in a similar
 107 manner. Past work indicates that appropriate music selections can have a positive impact on
 108 the experience of flow [28].

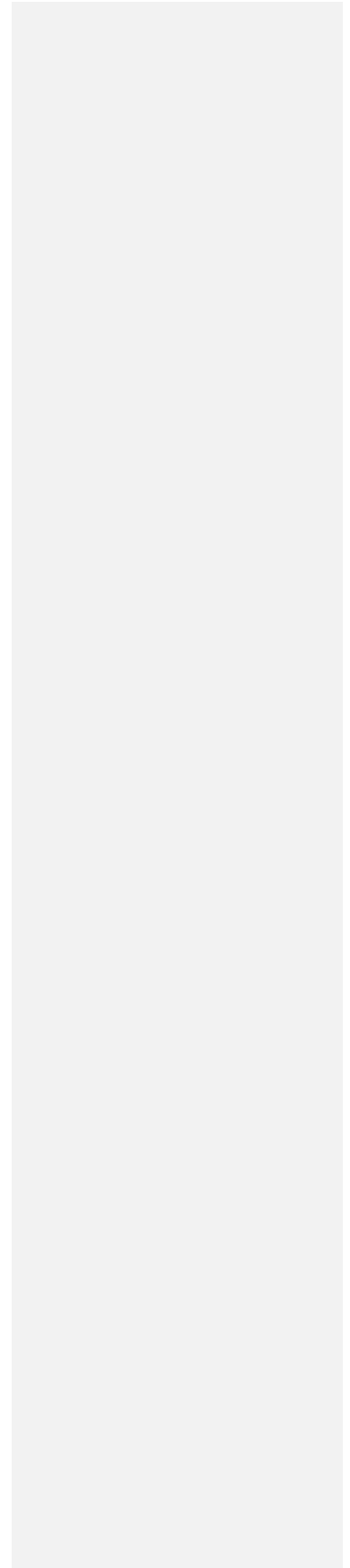
109

110 It was hypothesized that the mixed tempi music ~~tempi~~-condition would elicit significantly
 111 higher tempo preference scores, intrinsic motivation, and global flow, ~~and tempo preference~~
 112 ~~scores~~-when compared to the other conditions. ~~Moreover~~Also, the fast tempi condition would
 113 elicit the second highest scores and would exceed the medium tempi condition. Finally, all

114 three music tempi conditions were expected to yield higher scores on all dependent variables
115 when compared to a no-music control condition.

116

117



118 Materials and Methods

119 Stage 1: Music Selection

120 Following procurement of ethical approval and written informed consent for both stages of
121 the study, 118 undergraduates (mean age 20.2 ± 1.4 years) who were Caucasian and brought
122 up in Great Britain, were surveyed to establish their three favorite music artists for an exercise
123 context. These students matched the profile of the intended pool of experimental subjects both
124 in terms of age and socio-cultural background [24,20]. Following the survey, the three highest-
125 rated artists representing the women's favorite (*Basement Jaxx*), men's favorite (*The*
126 *Prodigy*), and the favorite across genders (*Queen*) were used.

127
128 ~~Eighteen~~ Nine tracks at medium tempi (115-120 ~~beats.min⁻¹ bpm~~) and nine tracks at fast
129 tempi (140-145 ~~beats.min⁻¹ bpm~~) ~~tempi~~ from each artist were rated by a panel of eight
130 subjects who regularly exercised to music. Earlier work had shown that differences between
131 these two tempi ranges were discernible during high intensity exercise (75% maxHRR) and
132 resulted in meaningful differences in music preference [18]. The rRating was conducted using
133 the Brunel Music Rating Inventory-2 [19] to standardize their motivational qualities of the
134 tracks. The "tempo" item was omitted as tempo constituted an independent variable in the
135 present design. This procedure was intended to ensure that, although the tempi between tracks
136 for each artist differed, there would be homogeneity in the motivational qualities of the music
137 so that this would not threaten internal validity. ~~A total of Twenty one~~ 21 tracks in total from
138 the three artists were discarded as a consequence.

139

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140 In preparation of music selections for the experimental trials, ~~For *Basement Jaxx*, 11 tracks~~
141 were recorded ~~for *Basement Jaxx* (five medium and six fast tempi),~~ 10 tracks for *The Prodigy*,
142 ~~10 tracks~~ (five medium and five fast tempi), and 12 tracks for *Queen*, ~~12 tracks~~ (six medium
143 ~~and six fast tempi~~). These tracks, which had similar motivational quotients at each of the two
144 tempi (~~16 tracks were of a medium tempo and 17 were of a fast tempo~~), were recorded onto
145 CDs with permission from the record companies. A different number of tracks were recorded
146 from each artist to ensure that the music programs were of equal duration.

147

148 **Stage 2: Experimental investigation**

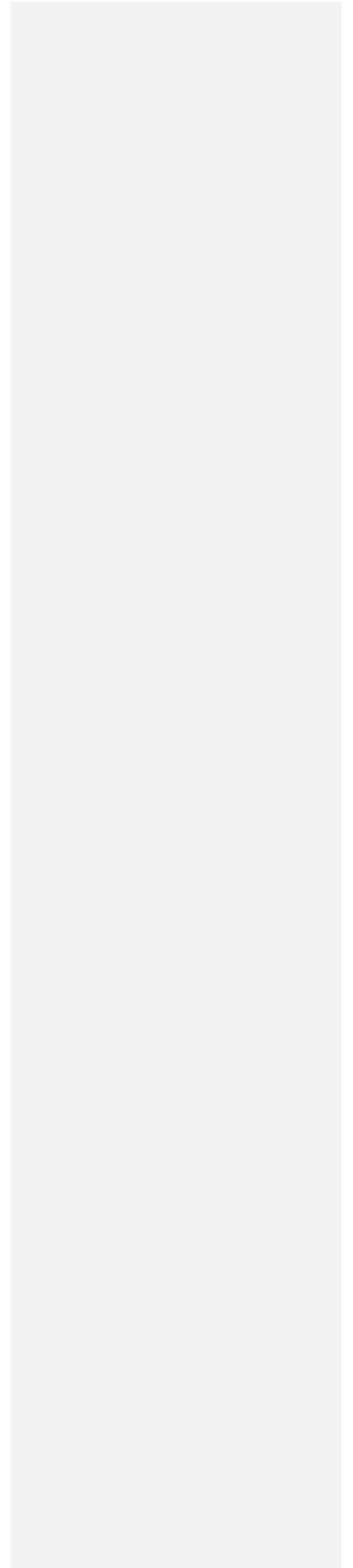
149 *Power analysis*

150 With alpha set at .05 and power at .7, based on an estimated moderate effect size (partial $\eta^2 =$
151 0.09) [18], it was calculated that approximately 30 subjects would be required.

152

153 *Subjects*

154 Twenty-nine volunteer subjects comprising 14 women (mean age 20.7 ± 1.1 years) and 15
155 men (mean age 20.4 ± 1.4 years) were selected from the student body at _____
156 Brunel University, West London. Subjects were Caucasians brought up in the United
157 Kingdom. They were homogeneous in terms of their age and socio-cultural background, as
158 these have been identified as factors that impact upon reactivity to music [21,20,24]. Also,
159 subjects were drawn from outfield positions in weight-bearing sports (e.g. field hockey,
160 netball, rugby union, soccer, etc.). This maintained some homogeneity in terms of their
161 cardiovascular fitness and appropriateness for the experimental task of treadmill walking. An
162 inducement of a prize draw was used to recruit subjects, with separate draws conducted for
163 women and men.



165

166 *Apparatus and measures*

167 A treadmill (Powerjog GXC200; Powerjog, Brigend, UK) was used for testing along with a
168 wall-mounted stereo system (Tascam CD-A500; Tascam, Tokyo, Japan) and a decibel meter
169 (GA 102 Sound Level Meter Type 1; Castle Associates, Scarborough, UK) to standardize
170 music intensity. Target heart rate was assessed using a heart rate monitor (Polar Accurex Plus;
171 Polar, Kempele, Finland) and a sensor held by the experimenter. Music preference at each of
172 the three work intensities was assessed using a single item: “Rate your preference for the
173 musical selections you have heard based on the work level you have just experienced” with
174 responses provided on a 10-point scale anchored by 1 (“not liked at all”) and 10 (“liked very
175 much”). To facilitate comparison with previous ~~research findings~~, this item was drawn from
176 Karageorghis et al. (2006)[18] to tap the suitability of the music for the work intensity of 70%
177 maxHRR, and appropriate explication was provided to subjects if required.

178

179 Intrinsic motivation for the treadmill walk was assessed using the IMI [31]. The IMI consists
180 of seven subscales of which only three were ~~used~~deemed relevant for the present study:
181 interest-enjoyment, pressure-tension, effort-importance. ~~All~~The IMI subscales have been
182 shown to be factor-analytically coherent and stable across a variety of tasks, conditions, and
183 settings. Items are rated on a seven-point Likert scale anchored by 1 (“strongly disagree”) and
184 7 (“strongly agree”). McAuley et al. [25] ~~recorded~~reported acceptable internal consistency
185 for all IMI subscales (e.g. interest-enjoyment $\alpha = .78$; pressure-tension $\alpha = .68$; effort-
186 importance $\alpha = .84$).

187

188 Flow state was assessed by means of the FSS-2 [~~46~~17] which is a 36-item inventory
189 comprised of nine subscales. Subjects were asked to indicate the extent of their agreement

190 with the items as representing their experience in the treadmill walking task they had just
191 completed. Responses were provided on a five-point Likert scale anchored by 1 (“strongly
192 disagree”) and 5 (“strongly agree”). The FSS-2 is psychometrically superior to the original
193 FSS and displayed a stable factor structure when tested across two independent samples.
194 Internal consistency estimates ranged ~~d~~ from .80-.90. In the interests of parsimony, we used a
195 *global flow score* representing the totality of the nine dimensions of flow.

196

197 *Pre-test and habituation trial*

198 Subjects were required to walk on a treadmill at a speed ~~corresponding with~~that would induce
199 an exercise intensity of 70% maxHRR. This was deemed to be an appropriate ~~exercise~~
200 intensity to differentiate preference between varying musical tempi without requiring subjects
201 to work at intensities involving significant anaerobic contribution to overall energy
202 expenditure. It has been shown that music is relatively ineffective as a dissociation tool or
203 ergogenic aid at high exercise intensities [~~73,763~~]. To ~~establish~~facilitate accurate assessment
204 of subjects’ maximal heart rate, they completed the Bruce protocol [~~68~~] and responded to an
205 ~~4011~~-point Ratings of Perceived Exertion (RPE) scale [~~5~~] each minute, beginning at the end
206 of the first minute. Subjects were instructed to endure the task for as long as possible, and
207 their maximal heart rate was recorded at the point of voluntary exhaustion using a heart rate
208 monitor. Women endured for 12.04 min (+ 1.38 min) while men endured for 13.38 min (+
209 1.39 min) The mean maximal heart rate achieved by women was 196.5 ~~beats.min⁻¹. bpm~~ (±
210 4.3) and 196.9 ~~beats.min⁻¹. bpm~~ (± 6.253) by ~~males~~men. In determining an appropriate
211 working heart rate for each subject, heart rate reserve was accounted for through application
212 of the Karvonen formula [~~22~~].

213

214 Subjects attended a habituation session at which the test protocol was explained and they were
215 familiarized with the velocity at which they would be working during each test trial. The
216 treadmill gradient was altered to obtain the desired exercise intensity rather than its velocity,
217 which was set at 6 kph. The rationale for this was to control for any potential synchronization
218 effect of stride rate with music tempo [2,26,3334]. In earlier piloting of the protocol and
219 previous published work [18], it was found that synchronization to music was not possible
220 during treadmill walking because stride rate is determined by treadmill velocity. During
221 treadmill running at low velocities, the opportunity does exist for the stride to either lengthen
222 or shorten to facilitate some synchronous movement. Nonetheless, one's gait needs to be
223 adjusted periodically, unless the treadmill belt is set to move in perfect synchrony with
224 musical tempo.

225

226 ***Experimental trials***

227 A repeated measures design was employed comprising three experimental conditions and one
228 control condition. Trials were scheduled at the same time of day for each subject over a 4-
229 week period. Conditions comprised treadmill walking at 70% maxHRR while subjects
230 listening to fast tempi music (140-145 beats.min⁻¹.bpm), medium tempi music (115-120
231 beats.min⁻¹.bpm), mixed tempi music (a series of tracks arranged in the order medium-fast-
232 fast-medium-fast-fast tempi), and a no-music control condition. Subjects were ~~required~~
233 requested to follow identical patterns of activity and diet ~~and with no~~ not to engage in any
234 other vigorous physical activity ~~permitted~~ prior to the trial on each of the test days.
235 ~~Further~~ Also, they were requested ~~not permitted to~~ refrain from eating a meal within 2 hours
236 prior to a trial. The order of conditions to which subjects were exposed was randomized and
237 they were administered each test individually.

238

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

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248
 249 Subjects performed stretches followed by a 2-min warm-up on the treadmill at a velocity of
 250 4.5 kph with no music and then at a constant velocity of 6 kph for each trial. ~~During earlier~~
 251 ~~piloting of a similar protocol [18], it was found that 6 kph would facilitate fast walking~~
 252 ~~without forcing subjects to break into a run.~~ The experimenter then took subjects to an
 253 exercise intensity corresponding with 70% maxHRR by raising the gradient of the treadmill
 254 until target heart rate was reached and maintained for a period of 1 min. Subjects selected the
 255 music of a single artist prior to their first experimental trial, and music of the same artist was
 256 used in each of the experimental trials. ~~On each test day, subjects were exposed to the music~~
 257 ~~of the artists they selected prior to their first experimental trial.~~ ~~This was done to avoid the~~
 258 influence of different artists impacting upon subjects' responses to music. ~~Indeed, p~~Previous
 259 research has indicated that ~~This was done to maintain internal validity given that the artist(s)~~
 260 can have a significant impact in determining music preference [87,3738].

261
 262 In cases where tracks deviated slightly from the required tempi (115-120 ~~beats.min⁻¹ bpm~~
 263 and 140-145 ~~beats.min⁻¹ bpm~~), they were digitally altered during recording to correspond

264 | with the required tempo range; however, any such alterations were so small as not to be
265 | discernible. There were no major deviations in tempo within tracks other than in the track
266 | Bohemian Rhapsody by Queen for which the slow introduction and outro were edited out.
267 | The tempo preference item, tThree subscales of the IMI, and the FSS-2 ~~and tempo preference~~
268 | ~~item~~ were administered immediately after each trial. The tempo preference item was not
269 | administered in the control condition.

270 |

271
272 *Data Analysis*

273 Data were screened for outliers and tested for the parametric assumptions underlying mixed-
274 model ANOVA and MANOVA [3536]. Music preference scores were assessed using a
275 mixed-model 2 x 3 (Gender x Condition) ANOVA while the IMI subscales and global flow
276 score were assessed using a mixed-model 2 x 4 (Gender x Condition) MANOVA.

277
278 **Results**

279 Data screening revealed no univariate or multivariate outliers. Tests of the distributional
280 properties of the data in each analysis cell revealed minor violations of normality in 17 of the
281 57 cells (30%; 13 at $p < .05$ and 4 at $p < .01$; Table 1). ANOVA and MANOVA are
282 sufficiently robust to withstand such minor violations of normality [23]. Also, violations were
283 not caused by outliers and none exhibited z skew/kurt ≥ 3.29 therefore a decision was taken
284 not to apply logarithmic transformation to the data [3536].

285
286 In the mixed-model ANOVA, Box's test was non-significant (Box's $M = 2.88$, $p > .05$) as
287 was Mauchly's test of sphericity (Mauchly's $W = .95$, $p > .05$). In the mixed-model
288 MANOVA, Box's test of equality of covariance matrices could not be computed as there
289 were fewer than two nonsingular cell covariance matrices. Accordingly, the Pillai's Trace
290 omnibus statistic was used in preference to Wilks' lambda [3536].

291
292 ~~Nonetheless,~~ Mauchly's test of sphericity was non significant for interest-enjoyment
293 (Mauchly's $W = .81$, $p > .05$), pressure-tension (Mauchly's $W = .94$, $p > .05$), and effort-
294 importance (Mauchly's $W = .78$, $p > .05$). It was significant for global flow (Mauchly's $W =$
295 0.23 , $p < .001$) indicating a need for Greenhouse-Geisser adjustment.

296
 297 ~~In the mixed-model ANOVA, Box's test was non-significant (Box's M = 2.88, $p > .05$) as~~
 298 ~~was Mauchly's test of sphericity (Mauchly's W = .95, $p > .05$).~~ Collectively, the battery of
 299 diagnostic tests indicated that the assumptions underlying a two-way mixed-model
 300 ~~M~~ANOVA and ~~M~~ANOVA were satisfactorily met and that the results would be generalizable
 301 to the population of Caucasian British university students.

303 *Interaction Effects*

304 The Gender x Condition interaction in the ~~M~~ANOVA was non significant, ~~$F_{2,1.90} = 2.97, p >$~~
 305 ~~$0.05, \eta_p^2 = .01$, as was the corresponding interaction in the MANOVA, Pillai's Trace = .55,~~
 306 ~~$F_{12,16} = .99, p > 0.05, \eta_p^2 = .04$, as was the corresponding interaction in the ANOVA, $F_{2,71.90} =$~~
 307 ~~$2.97, p > 0.05, \eta_p^2 = .01$~~ (see Table 1 and Figure 1). The interaction effects indicated that
 308 gender did not moderate ~~the motivational variables or preference~~ for music tempo or the
 309 motivation outcomes ~~for music tempo~~.

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311 *Main Effects*

312 ~~The ANOVA results showed that preference scores were highest~~ in the medium tempi
 313 ~~condition, $F_{2,1.9054} = 23.2922, p < 0.025, \eta_p^2 = .2211$, when compared to both the fastmixed~~
 314 ~~tempi condition, 95% CI = -0.0522 - 21.3822, $p < .0522$, and mixed-tempi conditions, 95% CI~~
 315 ~~$= 2.?? - 2.??, p < .??$ (Table 1).~~ The MANOVA indicated a main effect for all four dependent
 316 variables (Table 1; Pillai's Trace = .924, $F_{12,16} = 16.17, p > 0.001, \eta_p^2 = .92$): interest-
 317 enjoyment ($F_{3,81} = 48.70, p > 0.001, \eta_p^2 = .64$), pressure-tension ($F_{3,81} = 12.38, p > 0.001, \eta_p^2$
 318 $= .31$), effort-importance ($F_{3,81} = 3.31, p > 0.05, \eta_p^2 = .11$) and global flow ($F_{1.852,49.996} =$
 319 $25.79, p > 0.001, \eta_p^2 = .49$). Pairwise comparisons showed that interest-enjoyment was
 320 significantly higher for medium tempi when compared to mixed tempi, 95% CI = 1.80 - 8.48,

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321 $p < .001$, higher for medium tempi compared to control, 95% CI = 11.10-19.22, $p < .001$,
 322 higher for fast tempi compared to control, 95% CI = 7.96 - 17.32, $p < .001$, and higher for
 323 mixed tempi compared to control, 95% CI = 6.57 - 13.49, $p < .001$. Further, pressure-tension
 324 was significantly lower for medium tempi compared to control, 95% CI = -5.33 - -2.89, $p <$
 325 $.001$, for medium tempi compared to fast tempi, 95% CI = -3.44 - -0.19, $p < .05$, and for
 326 mixed tempi compared to control, 95% CI = -4.24 - -0.64, $p < .01$. In addition, global flow
 327 was significantly higher for medium tempi compared to control, 95% CI = 1.25 - 3.60, $p <$
 328 $.001$, for fast tempi compared to control, 95% CI = 0.89 - 3.14, $p < .001$, and mixed tempi
 329 compared to control, 95% CI = 1.36 - 3.76, $p < .001$.

330
 331 ~~Follow-up paired samples t tests indicated that global flow was significantly higher for~~
 332 ~~medium tempi when compared to fast tempi music, $t(28) = 2.08, p < .05$, for medium tempi~~
 333 ~~compared to control, $t(28) = 5.78, p < .001$, for fast tempi compared to control $t(28) = 5.19, p$~~
 334 ~~$< .001$, and for mixed tempi compared to control, $t(28) = 6.19, p < .001$.~~

335
 336 **Discussion**

337 ~~The purpose of this study was to examine the impact of three music tempi conditions on~~
 338 ~~intrinsic motivation, flow state and music preference during a long duration exercise task. The~~
 339 ~~study was an extension of a previous study [16] and built upon its recommendations for future~~
 340 ~~research. The results indicated that c~~Contrary to expectations, the medium tempi condition,
 341 rather than the mixed tempi and fast tempi conditions, elicited the highest levels of intrinsic
 342 motivation and flow. It was also the most preferred. More specifically, for interest-enjoyment
 343 the medium tempo condition proved superior to all other conditions. There was a
 344 corresponding effect found for pressure-tension – an antagonistic marker of intrinsic
 345 motivation – insofar as it was lowest in the medium tempi condition. Also, global flow was

346 highest in the medium tempi condition when compared to all other conditions. Similar to past
347 work [18], gender did not moderate the impact of the music tempi on either the motivation
348 variables or music preference.

349

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

363

364 We will interpret the results with reference to extant theory and related studies before
365 considering how methodological limitations may also have accounted for the unexpected
366 emergence of ~~mixed-medium~~ tempi as the most positive music condition. Higher tempi should
367 be preferred during exercise owing to because they reflect participants' physiological arousal
368 level [4,24]. the notion that the arousal potential of stimuli determines preference. When
369 physiological arousal is relatively high, there should be stronger preferences for faster tempi
370 [4,27]. In addition, such tempi are iconically representative [33] of high energetic arousal.

371 This means that they typically reflect the psychophysiological state of an individual engaged
372 in a bout of exercise.

373
374 The work intensity in the present study (70% maxHRR) was not quite as high as that used by
375 Karageorghis et al. (~~2006~~)[18] because the intention in the present study was for participants
376 to endure the exercise task rather than reach a pre-determined workload and then respond to a
377 piece of music. Thus, there may be a step change in preference threshold between 70% and
378 75% maxHRR ~~over in~~ which participants express a greater preference for fast tempi music.
379 This is also the point at which they begin to rely more upon anaerobic energy production and
380 become more acutely aware of physiological sensations [30]. In relation to this, although
381 some research has shown that music is ineffective in moderating levels of perceived exertion
382 at high intensities [3,-367] it can impact positively on subjective ratings of affect [76,14].

383
384 It is entirely plausible that a preference for medium tempi music was reported owing to the
385 phenomenon of *familiarity* [4,19,2021]. More specifically, in everyday listening situations,
386 exposure to medium tempi music is far more likely than exposure to fast tempi music. This
387 has to do with the fact that moderately arousing music is preferred in everyday listening
388 situations [4,14] and that most popular music is recorded at medium tempi than at slow and
389 fast tempi. Owing to repeated exposure to medium tempi music, preference is increased and
390 this, to a degree, may override the purported influence of physiological arousal [27].

391
392 Another plausible explanation for the present findings relates to self-determination theory and
393 satisfaction of the needs underlying intrinsic motivation [32]. The mixed tempi and fast tempi
394 conditions serve to “force the pace” a little and thus may undermine self-determination and
395 flow given that in an experimental situation subjects will not wish to fatigue themselves

396 excessively; particularly if involved in field sports. Hence, although subjects associated
 397 medium tempi with a “comfort zone”, the higher tempi music conditions may have reduced
 398 their sense of autonomy during the exercise task.

399

400 A limitation in the present study and in previous exercise-related research [18] is that gradual
 401 increases in music tempi have not been examined in conjunction with gradual increases in
 402 exercise intensity; rather, categories of tempi (e.g. slow, medium, and fast) and pre-
 403 determined exercise intensities have been used (e.g. 40% ~~maxHRR~~, 60% ~~maxHRR~~, and 75%
 404 maxHRR). It is also plausible that medium tempi music may be appropriate right up to
 405 anaerobic threshold after which fast tempi music is most preferred [16]. This line of research
 406 could be developed ~~could be further explored~~ through examining subtle increases in exercise
 407 intensity up to, and beyond anaerobic threshold, while subjects listen and respond to music of
 408 a wide range of tempi. It is notable that medium tempi and fast tempi music yielded more
 409 positive responses than the mixed-tempi music. This was also unexpected and points again to
 410 a possible preference threshold allied to anaerobic energy production that may govern
 411 responses to music tempo.

412

413 Although the ~~task of treadmill walking was performed asynchronously in nature and the use~~
 414 of such an externally-paced task made it particularly difficult for synchronization to occur,
 415 there is a possibility that ~~participants~~ subjects attempted, perhaps subconsciously, to
 416 synchronize their movements with rhythmical aspects of the music [21,20,33,34]. Given that
 417 walking is a relatively slow tempo motor skill, the use of fast tempi musical selections may
 418 have ~~created~~ resulted in some incongruence between the motor rhythm of the task and stimuli
 419 used; this is a limitation of the present study. Perhaps using a faster motor skill that required

420 the same work intensity (e.g. cycle ergometry) may have yielded findings more in line with
421 those predicted.

422

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

437

438 **Conclusions**

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

444

445 **Future Directions**

446 The present study warrants replication but with a more subtle manipulation of tempo in the
447 mixed tempo condition and with ~~using~~use of a range of exercise tasks. The duration of
448 exercise could also be extended in order that the tempo changes at least three times during
449 each exercise bout. The likelihood of a ~~threshold~~point at which there is perhaps a step change
450 in preference over which~~wherein~~ fast music tempi are most likely to be is~~is~~-preferred –
451 somewhere between 70-75% maxHRR – is hinted at within the present findings combined
452 with those of Karageorghis et al, ~~2006~~[18], therefore this phenomenon warrants further
453 investigation. An additional independent variable that should be considered by future
454 researchers is music intensity given the known influence of this variable on affect, arousal,
455 and motivation [10,13,29]. Finally, there is scope for additional examination of the
456 relationship between music preference, music tempo, and self-determination given that
457 preferred music, and tempi that match a particular motor rhythm, may facilitate a greater
458 sense of autonomy [32].

459

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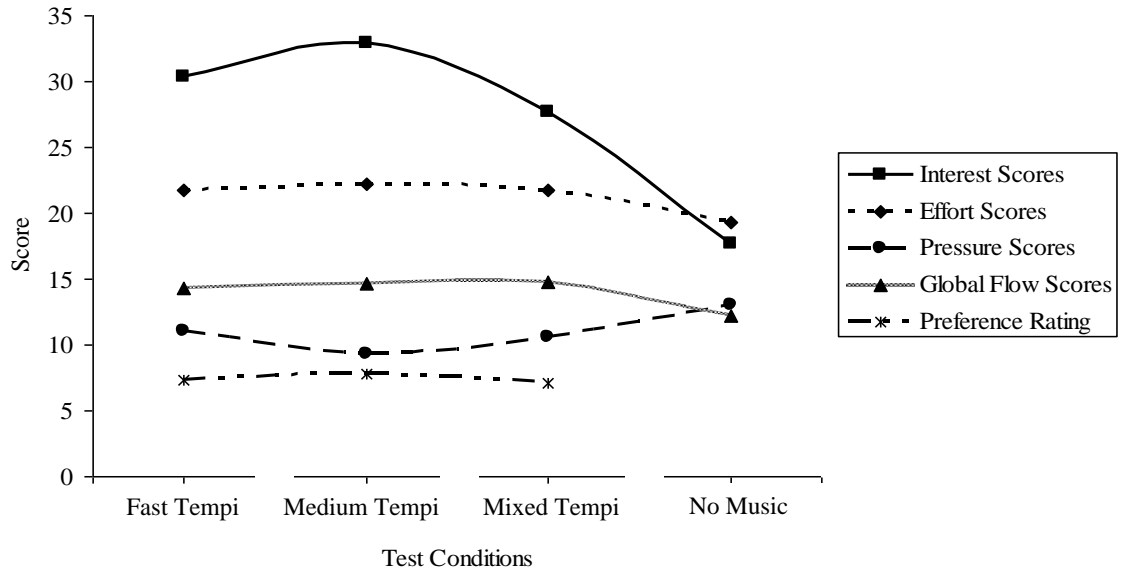
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Fig. 1 Combined male and female mean scores for IMI subscales, global flow, and preference ratings.



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

Independent variables		<i>M</i>	<i>SD</i>	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

