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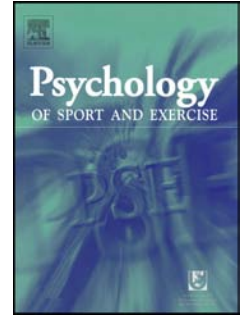
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# Accepted Manuscript

On the Role of Lyrics in the Music-Exercise Performance Relationship

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Running head: ROLE OF LYRICS IN EXERCISE

On the Role of Lyrics in the Music-Exercise Performance Relationship

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12 Abstract

13 *Objectives.* To examine the role of lyrics on a range of psychological, psychophysical, and  
14 physiological variables during submaximal cycling ergometry.

15 *Design.* Within-subject counterbalanced design.

16 *Method.* Twenty five participants performed three 6-min cycling trials at a power output  
17 corresponding to 75% of their maximum heart rate under conditions of music with lyrics,  
18 same music without lyrics, and a no-music control. Cycling cadence, heart rate, and perceived  
19 exertion were recorded at 2-min intervals during each trial. Positive and negative affect was  
20 assessed before and after each trial.

21 *Results.* Participants cycled at a higher cadence towards the end of the cycling trials under  
22 music with lyrics. Main effects were found for perceived exertion and heart rate, both of  
23 which increased from min 2 through to min 6, and for affect: positive affect increased and  
24 negative affect decreased from pre- to post-trials.

25 *Conclusions.* Participants pedalled faster in both music conditions (with and without lyrics)  
26 while perceived exertion and heart rate did not differ. The inclusion of lyrics influenced  
27 cycling cadence only at min 6 and had no effect on the remaining dependent variables  
28 throughout the duration of the cycling trials. The impact of lyrical content in the music-  
29 exercise performance relationship warrants further attention in order for us to better  
30 understand its role.

31

32 *Keywords:* affect, asynchronous music, cycle cadence, emotional contagion, ergogenic aid,  
33 lyrical component

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## On the Role of Lyrics in the Music-Exercise Performance Relationship

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Music is used to accompany all types of activities (e.g., driving, cooking, cleaning, writing, relaxing, exercising), whether this is to distract, energize, or provide a rhythmic cue for the listener (Sloboda, Lamont, & Greasley, 2009). In exercise and sport settings, the use of music has become extremely widespread (see Karageorghis & Priest, 2012a, 2012b, for a review); it is used as a means to enhance performance and evoke a range of physiological and psychological responses (Brownley, McMurray, & Hackney, 1995; Laukka & Quick, 2011; Razon, Basevitch, Land, Thompson, & Tenenbaum, 2009). In particular, music has been shown to enhance positive affect, which bears strong influence on an individual's intention to exercise and adhere to an exercise programme (Ekkekakis, Parfitt, & Petruzzello, 2011). Numerous studies have supported the use of *motivational music* to induce positive feelings during exercise (e.g., Crust, 2008; Hutchinson, Sherman, Davis, Cawthon, Reeder, & Tenenbaum, 2011). Typically, motivational music has a high tempo (> 120 bpm), catchy melodies, inspiring lyrics, an association with physical endeavour, and a bright, uplifting harmonic structure (Karageorghis, Terry, & Lane, 1999).

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The benefits of music use in the exercise domain have been attributed to a *rhythm response* or entrainment to music rhythm that has been associated with greater neuromuscular efficiency (e.g., Bacon, Myers, & Karageorghis, 2012), and the limited processing capacity of the central nervous system (e.g., Razon et al., 2009). Music competes with bodily cues in efferent neural pathways and thus blocks unpleasant cues replacing them with more positive ones (cf. Rejeski, 1985; Tenenbaum, 2001). Music in exercise has also been linked with a phenomenon known as *emotional contagion*, which refers to the process by which an exerciser "catches" (feels) emotion in response to music (see Juslin, 2009, for a review). The notion of emotional contagion (musically-induced/evoked emotions) has received support

59 from research in neuroscience (e.g., Koelsch, 2010; Koelsch, Fritz, von Cramon, Müller, &  
60 Friederici, 2006), which shows that listeners can understand the intended expression (e.g.,  
61 happiness or sadness) of the melody or lyrical content of music by perceiving the “motion” of  
62 the signal (Molnar-Szakacs & Overy, 2006).

63 Long-duration, repetitive exercise tasks such as rowing, running, and cycling,  
64 performed by recreationally active participants (not elite athletes) appear to be positively  
65 influenced by both asynchronous (background) and synchronous music (see Terry &  
66 Karageorghis, 2011, for a review). Additional benefits of music have been explained with  
67 reference to the dissociation effect (Rejeski, 1985), wherein music delays the onset of fatigue  
68 and allows individuals to increase work output/duration before internal negative sensations  
69 are perceived (Boutcher & Trenske, 1990). That is, perceptions of effort and fatigue diminish  
70 with the presence of music, thus participants are able to produce greater work output (e.g.,  
71 Elliott, Carr, & Savage, 2004).

72 The aforementioned benefits are load-dependent to a degree, given that music does not  
73 appear to moderate perceptions of effort at high exercise intensities ( $> 75\%$  maximal heart  
74 rate reserve [HRR<sub>max</sub>]; e.g., Karageorghis, Mouzourides, Priest, Sasso, Morrish, & Walley,  
75 2009). Nonetheless, in direct contrast with the posits of extant theory (e.g., Rejeski, 1985;  
76 Tenenbaum, 2001), music does appear to moderate affect even at very high intensities ( $> 85\%$   
77 HRR<sub>max</sub>; e.g., Hutchinson et al., 2011; Terry, Karageorghis, Mecozzi Saha, & D’Auria,  
78 2012). The combination of exercise with well-selected music can have a bearing on how  
79 people feel during as well as immediately after exercise (see Karageorghis & Jones, in press;  
80 Karageorghis, Jones, & Stuart, 2008). Indeed, the mood-enhancing properties of exercise per  
81 se have been particularly well documented (see e.g., Berger & Motl, 2000). Moreover,  
82 research has shown that post-exercise mood is enhanced/more positive when compared with

83 pre-exercise mood (e.g., Carels, Coit, Young, & Berger, 2007; Gauvin, Rejeski, & Norris,  
84 1996).

85 Numerous studies in the exercise domain indicate that people routinely use music to  
86 regulate emotions and affect for activities that vary in their physical intensity demand (e.g.,  
87 Brownley et al., 1995; Priest & Karageorghis, 2008). The neurophysiological concomitants of  
88 such benefits are as yet unknown; nonetheless, an important determinant of such affective  
89 qualities of music is the lyrical component, or words used in a song (Crust, 2008; Crust &  
90 Clough, 2006; Stratton & Zalanowski, 1994). While other constituents of music such as  
91 tempo (bpm) and loudness (dB) have garnered considerable attention from researchers  
92 (Brownley et al.; Edworthy & Waring, 2006; Karageorghis & Jones, in press), there is a  
93 dearth of research into the possible influence of lyrics, despite numerous qualitative and  
94 anecdotal accounts of their potential influence (e.g., Bishop, Karageorghis, & Loizou, 2007;  
95 Karageorghis et al., 2013; Priest & Karageorghis). Therefore, systematic investigation of the  
96 role of lyrics in the sport and exercise performance-relationship is warranted given both the  
97 widespread use of music in applied and research settings as well as the fact that lyrical music  
98 is often used in preference to instrumental music (Priest & Karageorghis, 2008).

99 The lyrical content of music is known to influence people's behaviour (see North &  
100 Hargreaves, 2008 for a review). For example, Jacob, Guéguen, and Boulbry (2010) found that  
101 listening to prosocial song lyrics during the eating (lunch and dinner) period in a restaurant  
102 increased patrons' tipping behaviours, in terms of both the proportion of customers leaving a  
103 tip and the amount of money they gave per tip. Greitemeyer (2009) showed that exposure to  
104 songs with prosocial lyrics fostered prosocial tendencies by increasing prosocial thoughts,  
105 affect, and behaviour in different situations (e.g., empathy towards others in need, donations  
106 to non-profit organizations, etc.).



107 Findings from the study of the effects of music with and without lyrics on mood and  
108 emotions are equivocal. Stratton and Zalanowski (1994) found that the lyrics of a song had  
109 greater capacity to alter mood than music without lyrics. More recently, Omar-Ali and  
110 Peynircioğlu (2006) asked participants to rate the intensity of four emotions (happy, sad,  
111 calm, and angry) in instrumental music or in music with lyrics. The authors found that melody  
112 had a stronger influence on emotion than lyrics. Nonetheless, in lyrical music, the lyrics  
113 “carry” the melody which adds a level of complexity in assessing the influence of lyrics and  
114 melody as singular phenomena.

115 Within the context of sport and exercise performance, lyrics may well relate to the task  
116 demands of repetitive activity (e.g., the potentially powerful influence of general affirmations  
117 [e.g., “Search for the hero inside yourself”]), task-specific verbal cues [e.g., “Keep on  
118 running”], and positive self-statements [e.g., “I am the one and only”]). In particular, lyrical  
119 content has been suggested to be the musical constituent that is most likely to promote a  
120 dissociation effect and thus reduce perceptions of effort (see Crust & Clough, 2006). Lyrics  
121 have also been suggested to play a role in inducing optimal mood and emotional states  
122 (Bishop et al., 2007; Crust, 2008; Laukka & Quick, 2011; Terry & Karageorghis, 2011).

123 The purpose of the present study was to examine the role of lyrics with reference to a  
124 range of psychological, psychophysical, and psychophysiological variables during  
125 submaximal cycle ergometry. It was hypothesized that, at the same individualized workload,  
126 cycling cadence would be significantly higher in the two music conditions (music with lyrics  
127 [ML] and music with no lyrics [NL]) when compared to a no-music control (NM), with the  
128 ML condition eliciting the largest increase in cycle cadence ( $H_1$ ); as is common in the  
129 exercise science literature (e.g., Karageorghis et al., 2009) heart rate was used as a proxy for  
130 physiological stress and was expected to increase equally across the three conditions  
131 throughout the cycling task ( $H_2$ ); perceived exertion (the feeling of how heavy and strenuous

132 a physical task is; Borg, 1998, p. 8), was expected to be lower in the two music conditions  
133 when compared to NM ( $H_3$ ); lastly, positive affect would increase and negative affect would  
134 decrease from pre- to post-test trials, in all three conditions ( $H_4$ ), with distinct trends observed  
135 for positive affect (ML > NL > NM) and negative affect (NM > NL > ML).

136

### Methodology

137 Ethical approval was gained from the ethics committee of the UK university at which  
138 the research was conducted and participants provided written informed consent. The research  
139 consisted of two phases: music selection (Stage 1) and the experimental protocol (Stage 2).

#### 140 Stage 1: Music Selection

141 **Participants.** Forty-nine undergraduate students ( $M_{\text{age}} = 19.9$  years,  $SD = 1.2$  years)  
142 from a sport and exercise science undergraduate course at a university in northern England,  
143 UK volunteered to participate in the selection of motivational musical tracks for use in the  
144 experimental phase of the study. In keeping with the methodological guidelines of  
145 Karageorghis and Terry (1997), these participants were of a similar socio-cultural background  
146 and age profile to participants in Stage 2.

147 **Measures.** The Brunel Music Rating Inventory-2 (BMRI-2; Karageorghis, Priest, Terry,  
148 Chatzisarantis, & Lane, 2006) was employed to select the tracks that would be used in Stage  
149 2. This questionnaire was designed to measure the motivational qualities of music for use in  
150 an exercise environment. It is a single-factor, six-item instrument presented on a 7-point  
151 Likert-scale anchored by 1 (*strongly agree*) and 7 (*strongly disagree*). For the purposes of the  
152 study, participants were informed that the word “motivate” meant music that would “make  
153 you want to exercise harder and/or longer in a cycling performance task”. The mean Cronbach  
154 alpha coefficient for the single factor reported by the authors was .89 (Karageorghis et al.,  
155 2006). Cronbach alpha coefficients in our study were .95 for both the rating of songs with  
156 lyrics and for the rating of those without.

157           **Procedures.** Participants were randomly assigned to one of two groups that were tasked  
158 with assessing the motivational qualities of eight tracks containing lyrics ( $n = 27$ ; 15 males  
159 and 12 females;  $M_{\text{age}} = 20.1$  years,  $SD = 1.3$  years) or the same tracks without lyrics ( $n = 22$ ;  
160 13 males and 9 females;  $M_{\text{age}} = 19.7$ ,  $SD = 1.0$  years). The decision to use two independent  
161 groups was taken to prevent any intra-individual comparison of the two versions of each  
162 track, which were identical with the exception of the presence/absence of lyrics. Testing time  
163 and room conditions were the same for both groups. Initially, all participants listened to the  
164 same piece of calming instrumental music for 2 min as a baseline (62 bpm; *Woodland*  
165 *Wonder* from the album *Instrumental Sounds of Nature*). They then listened to the given  
166 music track for 90 s and rated that track using the BMRI-2; a process that was repeated for  
167 each of the eight tracks. Music was delivered through a compact disc player (Bush Digital  
168 Portable). Volume (loudness) was standardized for all music tracks at 70 dBA, which is  
169 deemed safe from an audiological perspective (Lindgren & Axelsson, 1988).

170           **Data Analysis.** The purpose of the analyses employed in Stage 1 was to identify two  
171 tracks (i.e., a sufficiently long accompaniment for the 6-min cycling test) for use in Stage 2  
172 with significantly ( $p < .05$ ) higher BMRI-2 scores for the versions with lyrics. Data screening  
173 and diagnostic tests (normal distribution of data and homogeneity of variance) to ensure data  
174 were suitable for parametric analysis were performed (Tabachnick & Fidell, 2007, pp. 60–  
175 116). A separate mixed-model 2 (Group [lyrics/no lyrics]) x 8 (Track) ANOVA and follow-up  
176 analyses were computed to find the two pairs of tracks required for the experimental phase.  
177 Mauchly's test was used to check the sphericity assumption and where this assumption was  
178 violated, the corresponding  $F$  ratio was subjected to Greenhouse-Geisser adjustment. Partial  
179 eta squared ( $\eta_p^2$ ) effect sizes were computed and, in accordance with Cohen (1988, pp. 184–  
180 185),  $\eta_p^2$  of .01-.03, .06-.09 and above .14 indicate a small, medium and large effect,  
181 respectively.

182           **Results.** Data screening of the BMRI-2 results revealed that there was one case that  
183 exhibited multiple univariate outliers and this was deleted prior to further analysis. Overall,  
184 the BMRI-2 data did not meet the normality assumption owing to substantial positive  
185 standard skewness (standard skew. > 3.29) and positive standard kurtosis (standard kurt.  $\geq$   
186 3.29) in five cells of the analysis; therefore, a logarithmic transformation—suitable for this  
187 type of nonnormality— was applied to normalize these data (see Tabachnick & Fidell, pp.  
188 86–91).

189           A mixed-model ANOVA on the transformed BMRI-2 scores showed a significant  
190 Group x Track interaction,  $F(4.89, 224.79) = 6.62, p < .001, \eta_p^2 = .13$ , and a main effect for  
191 the selected tracks,  $F(4.89, 224.79) = 8.38, p < .001, \eta_p^2 = .15$ . Tracks with lyrics ( $M = 1.14$ ,  
192  $SE = .02$ ) were not, overall, rated as significantly ( $p = .526$ ) more motivational than tracks  
193 without lyrics ( $M = 1.12, SE = .02$ ). However, for the tracks for which the version with lyrics  
194 was rated as more motivational than the version without, follow-up analyses using standard  
195 errors indicated significant ( $p < .05$ ) differences between the two versions of *Uninvited* (ML:  
196  $M = 1.34, SE = .04$  and NL:  $M = 1.07, SE = .04$  [transformed data]) and the two versions of  
197 *Firestarter* (ML:  $M = 1.20, SE = .05$  and NL:  $M = 1.04, SE = .05$  [transformed data]).  
198 Accordingly, these two tracks were selected for use in Stage 2 (see Table 1 for details of all  
199 eight tracks).

## 200 **Stage 2: Experimental Investigation**

201           **Participants.** Given the dearth of studies examining the role of lyrics in the music-  
202 exercise performance relationship, we used our preliminary data to conduct a power analysis  
203 and thus establish an appropriate sample size. A power calculation (Faul, Erdfelder, Buchner,  
204 & Lang, 2009) based on a large effect size ( $\eta_p^2 = .28$ ) indicated that 23 participants would be  
205 required. As a protection against experimental dropout and multivariate outliers, a total of 25  
206 undergraduate students (11 women and 14 men;  $M_{age} = 20.8$  years,  $SD = 1.3$  years) from a

207 sport and exercise science course at a university in northern England, UK were recruited to  
208 take part in Stage 2. These participants were different than those used in Stage 1.

209 **Instruments and Procedures.** All participants reported a liking for mainstream dance  
210 music and were physically active in accordance with the American College of Sports  
211 Medicine and the American Heart Association criteria; these entail partaking in 150 min (30  
212 min for 5 days per week) of moderate exercise, or 60 min (20 min for 3 days per week) of  
213 vigorous-intensity exercise (Haskell et al., 2007). Participants were asked to refrain from  
214 consuming caffeine-based products and exercising for 24 hr prior to testing.

215 **Graded exercise test (GXT).** To establish the workload for each participant during the  
216 experimental and control conditions, they first performed a continuous and incremental  
217 graded exercise test on a cycle ergometer (Corival). This session also facilitated participants'  
218 familiarization with the cycling procedures and associated measurements of exercise  
219 intensity. With the ergometer in hyperbolic mode, participants performed a 5-min warm-up at  
220 80 W after which the power output was increased by 40 W every 3 min until the point of  
221 voluntary exhaustion. Cessation of the test was determined primarily by a heart rate (HR)  
222 within  $\pm 10$  bpm of age-predicted maximum, volitional exhaustion or an inability to maintain  
223 pedal/cycling cadence above 60 revolutions per minute (RPM; Eston, Faulkner, Gibson,  
224 Noakes, & Parfitt, 2007). During the last 30 s of each increment of the GXT, we recorded HR  
225 using a heart rate monitor (FS1) and ratings of perceived exertion (RPE) using Borg's (1982)  
226 6-20 scale. Past research has shown the appropriateness of these measures for assessing effort  
227 and perceived exertion during physical work (see e.g., Hardy & Rejeski, 1989).

228 Prior to commencing the test, participants were instructed in how to respond to the RPE  
229 scale (Borg, 1998, pp. 43–52). Linear regression was subsequently used to calculate the  
230 power output for each participant, which corresponded to 75% of their maximum heart rate  
231 ( $HR_{max}$ ) attained during the GXT. The calculated power output was then used as the

232 exercising workload during the experimental and control trials. This workload was selected  
233 on the basis of previous training studies that have used heart rate as a method by which to  
234 control exercise intensity (e.g., Kaikkonen, Yrjämä, Siljander, Byman, Laukkanen, 2000), and  
235 because the psychophysical effects of music are attenuated beyond this intensity (see Rejeski,  
236 1985; Tenenbaum, 2001).

237 ***Experimental exercise trials.*** The experimental conditions, which were administered  
238 on different days separated by at least a day's rest and presented in counterbalanced order,  
239 comprised music with lyrics (ML), the same piece without lyrics (i.e., an instrumental piece;  
240 NL) and a no-music control (NM). Each condition consisted of a 3-min warm-up at 50 W  
241 followed by a 6-min exercise bout at the pre-established workload for each participant. The  
242 cycle ergometer was set in order that workload remained constant throughout each 6-min trial,  
243 independent of the cycling cadence selected by the participant. Measures of RPM, HR, and  
244 RPE were monitored and recorded every 2 min during each trial, with RPM obscured from  
245 the participant's view to discourage engagement in any goal-setting strategies during testing.  
246 Music was delivered through in-ear phones (iPod) connected to a compact disc player (same  
247 as above). Volume (loudness) was standardized for all testing procedures at 70 dBA. the two  
248 songs selected in Stage 1, that is *Uninvited* by Freemasons (lyrics available from  
249 <http://www.metrolyrics.com/uninvited-lyrics-freemasons.html>) and *Firestarter* by The  
250 Prodigy (lyrics available from <http://www.metrolyrics.com/firestarter-lyrics-prodigy.html>),  
251 were edited in order to be played from the beginning for 3 min each, thus matching the test  
252 duration. During the NM condition, a blank compact disc was played. All conditions were  
253 performed at the same location, at the same time of day ( $\pm 2$  hr), and were completed within  
254 10 days of the GXT. The first experimental exercise trial was separated by at least 48 hr from  
255 the end of the GXT to allow participants full recovery.

256 Participants were also instructed to complete the International Positive and Negative  
257 Affect Schedule Short Form (I-PANAS-SF; Thompson, 2007) prior to and immediately after  
258 each trial. This questionnaire has 10 items presented on a 5-point Likert scale anchored by 1  
259 (*never*) and 5 (*always*). Sample items include “inspired” (positive affect; PA) and “upset”  
260 (negative affect; NA). Participants were instructed to answer each item using a “how do you  
261 feel right now?” response set. The Cronbach alpha coefficients reported by the author are .78  
262 for the PA subscale and .76 for the NA subscale. Cronbach alpha coefficients in the present  
263 study ranged from .71 to .92 for PA and NA pre- and post-trial in each condition.

264 **Data Analysis.** Similar data screening and diagnostic tests were used to those detailed  
265 in Stage 1. A two-factor 3 (Music Condition) x 2 (Time) repeated measures (RM) ANOVA  
266 was computed for RPM and MANOVAs using the same model were computed for PA and  
267 NA, and RPE and HR. One-way RM MANOVA was computed to assess mean RPE and HR  
268 data. Pairwise comparisons with Bonferroni adjustments were used where necessary.

269 **Results.** One univariate outlier was identified and reduced by modifying the raw score  
270 towards the mean, to a unit below the next less extreme raw score (Tabachnick & Fidell,  
271 2007, p. 77). The data were normally distributed (standard skew./kurt.  $\leq 2.58$ ) with the  
272 exception of the negative and positive affect data which showed moderate positive skewness  
273 in four cells of the analysis. Given the moderate nature of this violation, a square root  
274 transformation was sufficient to normalize the affect data (see Tabachnick & Fidell, pp. 86–  
275 91).

#### 276 **Interaction Effects**

277 The two-factor RM ANOVA for RPM revealed a significant Condition x Time  
278 interaction,  $F(4, 96) = 3.89, p = .006, \eta_p^2 = .14$ , with a large effect size. Follow-up tests  
279 indicated that at min 6, RPM was significantly ( $p = .010$ ) higher in the ML ( $M = 100.60, SE =$   
280  $4.63$ ) condition when compared to NL ( $M = 96.20, SE = 4.70$ ), but that there were no such

281 differences at min 2 and 4 (see Figure 1). The same interaction in a RM MANOVA was  
282 nonsignificant for PA and NA, Hotteling's Trace = .13,  $F(4, 92) = 1.51$ ,  $p = .194$ ,  $\eta_p^2 = .06$ . In  
283 a separate RM MANOVA, the same interaction was nonsignificant for RPE and HR, Pillai's  
284 Trace = .119,  $F(8, 192) = 1.52$ ,  $p = .152$ ,  $\eta_p^2 = .06$ .

### 285 Main Effects

286 There was a condition main effect for RPM,  $F(2, 48) = 18.49$ ,  $p < .001$ ,  $\eta_p^2 = .43$ ,  
287 associated with a large effect size, with pairwise comparisons indicating that the highest RPM  
288 was recorded in the two music conditions ( $p < .001$ ). There was also a time main effect for  
289 RPM,  $F(1.15, 27.70) = 31.66$ ,  $p < .001$ ,  $\eta_p^2 = .57$ , again associated with a large effect size,  
290 with pairwise comparisons indicating that RPM increased in a linear manner throughout the  
291 duration of the 6-min exercise bout ( $p < .01$ ; see Figure 1).

292 There was no condition main effect for PA and NA, Hotteling's Trace = .01,  $F(4, 92) =$   
293 .14,  $p = .966$ ,  $\eta_p^2 = .01$ , although there was a main effect for time, Hotteling's Trace = 4.03,  
294  $F(2, 23) = 46.32$ ,  $p < .001$ ,  $\eta_p^2 = .80$ , associated with a large effect size. Stepdown  $F$  tests  
295 indicated differences for PA,  $F(1, 24) = 68.53$ ,  $p < .001$ ,  $\eta_p^2 = .74$ , and NA,  $F(1, 24) = 28.93$ ,  
296  $p < .001$ ,  $\eta_p^2 = .55$ , with pairwise comparisons revealing that PA increased from pre- to post-  
297 task while NA decreased ( $p < .001$ ; see Table 2).

298 There was no condition main effect for RPE and HR, Pillai's Trace = .15,  $F(4, 96) =$   
299 1.98,  $p = .104$ ,  $\eta_p^2 = .08$ , although there was a main effect for time, Pillai's Trace = .74,  $F(4,$   
300 96) = 14.11,  $p < .001$ ,  $\eta_p^2 = .37$ , associated with a large effect size. Stepdown  $F$  tests indicated  
301 differences for RPE,  $F(1.13, 27.12) = 39.41$ ,  $p < .001$ ,  $\eta_p^2 = .62$ , and HR,  $F(1.15, 27.62) =$   
302 56.78,  $p < .001$ ,  $\eta_p^2 = .70$ , with pairwise comparisons revealing that both RPE and HR  
303 increased in a linear manner throughout the duration of the task ( $p < .001$ ; see Table 3).

304

### Discussion



305 The present study examined the role of the musical constituent of lyrics with reference  
306 to a range of psychological, psychophysical, and physiological variables during submaximal  
307 cycle ergometry. Two main findings emerged: First, musical accompaniment per se resulted  
308 in a higher cycling cadence and this was manifest without any corresponding increase in  
309 perceived effort or heart rate. The condition with lyrics elicited a higher cadence (RPM) than  
310 the condition without *only* at min 6, therefore  $H_1$ , stating that RPM would be significantly  
311 higher in the two music conditions, is partially supported. Second, the inclusion of lyrics had  
312 no bearing on the remaining psychological (affect), psychophysical (RPE), and physiological  
313 (HR) variables. Therefore  $H_2$ , stating that HR was expected to increase equally across the  
314 three conditions throughout the task, is accepted, while  $H_3$ , stating that RPE would be lower  
315 in the two music conditions, and  $H_4$ , stating that positive affect would increase and negative  
316 affect decrease from pre- to post-test in all three conditions (with distinct trends to be  
317 observed for positive affect [ML > NL > NM] and negative affect [NM > NL > ML]), are not  
318 supported by the present data. Main effects for time were found for RPE and HR, both of  
319 which increased from min 2 through to min 6 of the task, and for affect: positive affect  
320 increased and negative affect decreased from pre- to post-trial.

321 The present findings reveal that both music with lyrics and music without elicited  
322 significantly ( $p = .006$ ) greater mean cycling cadence (RPM) throughout the cycling test than  
323 the no-music control condition. This adds to an emerging literature that supports the potential  
324 of music to aid physical performance (e.g., Crust & Clough, 2006; Karageorghis et al., 2013;  
325 Terry et al., 2012). In addition, the findings support those of previous studies that used similar  
326 protocols, and reported no changes in physiological indices (e.g., blood lactate concentration)  
327 with a concomitant increase in RPM (e.g., Lim, Atkinson, Karageorghis, & Eubank, 2009).  
328 An increase in cycling cadence without a corresponding increase in heart rate could be  
329 attributed to participants' entrainment to the rhythmical qualities of music, which is likely to

330 engender more efficient movement patterns (Terry et al., 2012). Recent research by Bacon et  
331 al. (2012) has found that participants required 7% less oxygen when cycling in time to the  
332 beat of the music when compared to an asynchronous music condition at a slightly slower  
333 tempo. Similarly, in the first study to examine the effects of synchronous music with elite  
334 athletes (triathletes), Terry et al. (2012) found that oxygen consumption during treadmill  
335 running was 1.0-2.7% lower with music (whether motivational or neutral), when compared  
336 against a no-music control.

337         The matching of a music playlist to the requirements of a given activity has been  
338 identified as an important factor when investigating the effects of music on performance  
339 (Atkinson, Wilson, & Eubank, 2004; Karageorghis et al., 1999). In line with past research  
340 (e.g., Elliott, Carr & Savage, 2004), participants in our study may have derived benefit from  
341 the rhythmical qualities of the music (tempo  $\geq$  128 bpm) in terms of maintaining a regular  
342 movement pattern. Nonetheless, contrary to expectations, exercising with music with lyrics  
343 did not result in higher cycling cadence when compared to exercising with music that had no  
344 lyrics. This study is the first to experimentally examine the impact of lyrics in the music-  
345 physical performance relationship; hence, a direct comparison with previous findings is  
346 somewhat challenging. Previous research does indicate, however, that music differing in its  
347 motivational qualities elicits significant differences during exercise (Elliott et al.;  
348 Karageorghis et al., 2006, 2009). Also, fatigue may inhibit participants from processing  
349 lyrical content in a similar way to that at rest (cf. Tenenbaum, 2001). Despite the fact that past  
350 empirical research has not addressed this issue directly, it seems entirely plausible that such  
351 syntactical content would be challenging to process at high exercise intensities owing to the  
352 automatic attentional switching that apparently takes place beyond the anaerobic threshold  
353 (Rejeski, 1985).

354 In the present study, the higher cycling cadence reported in the two music conditions  
355 was not accompanied by concomitant increases in perceived exertion; this supports the  
356 findings of similar studies (e.g., Lim et al., 2009). The primary reason for a lower perceived  
357 exertion despite the higher work-rate relates to the dissociation promoted by music listening,  
358 which limits the fatigue-related sensations transmitted via the efferent nervous system  
359 (Hutchinson et al., 2011; Rejeski, 1985). Given that most research in this area has focused on  
360 protocols of longer durations than our 6-min submaximal test (e.g., Boutcher & Trenske,  
361 1990; Karageorghis et al., 2009), further research examining a longer bout of exercise  
362 accompanied by an entire music programme with and without lyrics is recommended.

363 As expected, the present findings showed an increase in positive affect and a decrease in  
364 negative affect post-exercise, for all conditions. This is in line with past research that supports  
365 the beneficial role of exercise with reference to a range of psychological state variables (e.g.,  
366 Carels et al., 2007). However, contrary to expectations, neither the presence of instrumental  
367 music nor the presence of music with lyrics influenced participants' affective states when  
368 compared to a no-music control. This does not concur with past findings, which have shown  
369 an enhancement in affect associated with music conditions when compared to no-music  
370 controls (e.g., Boutcher & Trenske, 1990; Karageorghis et al., 2009; Terry et al., 2012). It has  
371 also been suggested that individuals can be emotionally aroused by the lyrical content of  
372 music and the manner of its vocal delivery (see North & Hargreaves, 2008; Priest &  
373 Karageorghis, 2008). Such emotional responses to music could implicate a mirror neuron  
374 mechanism (Molnar-Szakacs & Overy, 2006), which is so called because it is activated both  
375 when the individual acts and observes the same action performed by another. Mirror neurons  
376 have been proposed as a mechanism that allows "...an individual to understand the meaning  
377 and intention of a communicative signal by evoking a representation of that signal in the  
378 perceiver's own brain." (Molnar-Szakacs & Overy, p. 235). This mechanism may also relate

379 to the earlier described notion of emotional contagion wherein the listener “catches” the  
380 emotion that a composer or artist seeks to convey through music (Juslin, 2009). Accordingly,  
381 there is a necessity for neurophysiological investigation of the influence of lyrics and vocal  
382 delivery within exercise and sport settings. Such research might cast light on the mechanisms  
383 and neural circuits that underlie how these aspects of music influence affective and  
384 performance-related outcomes (e.g., exercise endurance).

### 385 **Limitations and Recommendations**

386 Music selection in the present study was conducted at rest whereas experimental testing  
387 required participants to perform a submaximal exercise task. In the field of sport and exercise  
388 sciences, it is common for music selected to be conducted while participants are at rest. The  
389 approach in our domain mirrors that in mainstream psychology wherein studies of the  
390 influence of lyrics have generally been conducted with participants in a restful state (e.g., in a  
391 restaurant setting; see Jacob et al., 2010). Nevertheless, given the specifics of the sport and  
392 exercise domain, researchers in this field might consider conducting music selection under  
393 conditions that mirror the modalities and intensities of the activity that will be used in  
394 subsequent experimental trials (e.g., cycling at a high intensity or running at a moderate  
395 intensity). Currently, the BMRI and its derivatives require respondents to rate a given piece of  
396 music with an exercise task in mind, rather than while actually performing that task.

397 The tracks used in Stage 2 of the study were preselected in Stage 1 according to their  
398 motivational properties for exercise by participants of a similar socio-cultural background and  
399 age profile to participants who took part in Stage 2 (cf. Karageorghis & Terry, 1997). Past  
400 research has shown that it may be beneficial to include self-selected pieces in the study of the  
401 music-performance relationship (e.g., Razon et al., 2009; Terry et al., 2012). Although a wide  
402 range of music has been used in past research to examine its effect on performance, such  
403 music has generally not been selected with explicit reference to its lyrical content. From an

404 applied practitioner perspective, the lyrical content of music can enhance affect as well as  
405 provide positive affirmations or task-related verbal cues (e.g., Crust, 2008; Laukka & Quick,  
406 2011; Priest & Karageorghis, 2008). Moreover, had the present protocol been of a longer  
407 duration, symptoms of fatigue may have been more likely to impinge on attentional processes,  
408 rendering the exercise to be more pleasurable in the presence of music (e.g., Elliott et al.,  
409 2004; Karageorghis et al., 2009).

410 In the present study, the experimental manipulation that we employed entailed using  
411 instrumental versions of tracks that were commonly heard with lyrics. Given that the  
412 composers of these tracks had conceived them with the presence of lyrics, we do not know  
413 how participants would respond to music that had been composed to be purely instrumental in  
414 nature; such music uses the meshing of instrumental sounds to elicit an emotional response in  
415 the listener. Past research that has examined music, emotions, and lyrics has shown that  
416 interpretation of the lyrics (e.g., the truthfulness of the words, the message of the lyrics)  
417 influences the overall emotional experience of music (see e.g., Juslin, 2009 for a review).

418 In addition, neither the meaning of the lyrics nor how participants interpreted them was  
419 considered in the present study. The songwriters' intended meaning compared against the  
420 typically diverse interpretation of listeners indicates that future researchers might consider  
421 both the lyrical content of tracks and individual interpretations (Priest & Karageorghis, 2008).  
422 Researchers should also account for the possibility of lyrics being heard via auditory imagery  
423 during a no-lyrics condition; the selected songs in the present study were top 10 hits in the  
424 UK charts and thus generally well known. Both of the aforementioned limitations could be  
425 assuaged through the use of music that was previously unfamiliar to participants.

426

### Conclusions

427 The present study supported the notion that carefully selected music can engender an  
428 ergogenic effect in an exercise task. Participants' cycling cadence increased in a short-

429 duration, individually fixed-load cycling bout when compared to performance in a no-music  
430 control condition. The presence of lyrics bolstered the ergogenic effect of the music only in  
431 the closing stages of the trial (min 6), although the tracks with lyrics were delineated as being  
432 more motivating for exercise than the same tracks without lyrics. Sport and exercise  
433 psychology researchers suggest that lyrics can play an important role in sport and exercise  
434 settings through the affirmations or task-relevant cues they provide (e.g., Bishop et al., 2007;  
435 Terry & Karageorghis, 2011). Thus, the lyrical content of music warrants further investigation  
436 in order that we might better understand its role and harness its motivational and affective  
437 properties.

438

439

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Table 1

*BMRI-2 Scores (Mean and Standard Deviation) for Tracks with Lyrics (ML; n = 26) and Tracks without Lyrics (NL; n = 22)*

| Track No. | Song Title         | Artist                           | Music Condition | BMRI-2        |
|-----------|--------------------|----------------------------------|-----------------|---------------|
| 1         | Now You're Gone    | Basshunter                       | ML              | 12.31 (6.12)  |
|           |                    |                                  | NL              | 11.41 (4.64)  |
| 2         | It's Over Now      | Big Ang ft. Siobham              | ML              | 14.19 (7.83)  |
|           |                    |                                  | NL              | 15.60 (5.95)  |
| 3         | Yeah Yeah          | Bodyrox                          | ML              | 15.42 (7.59)  |
|           |                    |                                  | NL              | 19.09 (7.98)  |
| 4         | Perfect (Exceeder) | Mason vs. Princess Superstar     | ML              | 14.27 (6.60)  |
|           |                    |                                  | NL              | 15.32 (5.75)  |
| 5         | Uninvited          | Freemasons                       | ML              | 23.15 (7.34)  |
|           |                    |                                  | NL              | 13.45 (6.99)  |
| 6         | I Like To Move It  | Real 2 Real ft. The Mad Stuntman | ML              | 11.88 (5.44)  |
|           |                    |                                  | NL              | 12.45 (7.76)  |
| 7         | Crazy In Love      | Beyoncé                          | ML              | 17.73 (7.60)  |
|           |                    |                                  | NL              | 18.41 (7.29)  |
| 8         | Firestarter        | The Prodigy                      | ML              | 18.42 (10.53) |
|           |                    |                                  | NL              | 12.27 (6.09)  |

*Note.* The descriptive statistics recorded here are pre-transformation (see text for further details).

Table 2

*Positive Affect (PA) and Negative Affect (NA) Values (Mean and Standard Deviation) before (pre-trial) and after (post-trial) Cycling under Conditions of Lyrics, No Lyrics and a No-music Control*

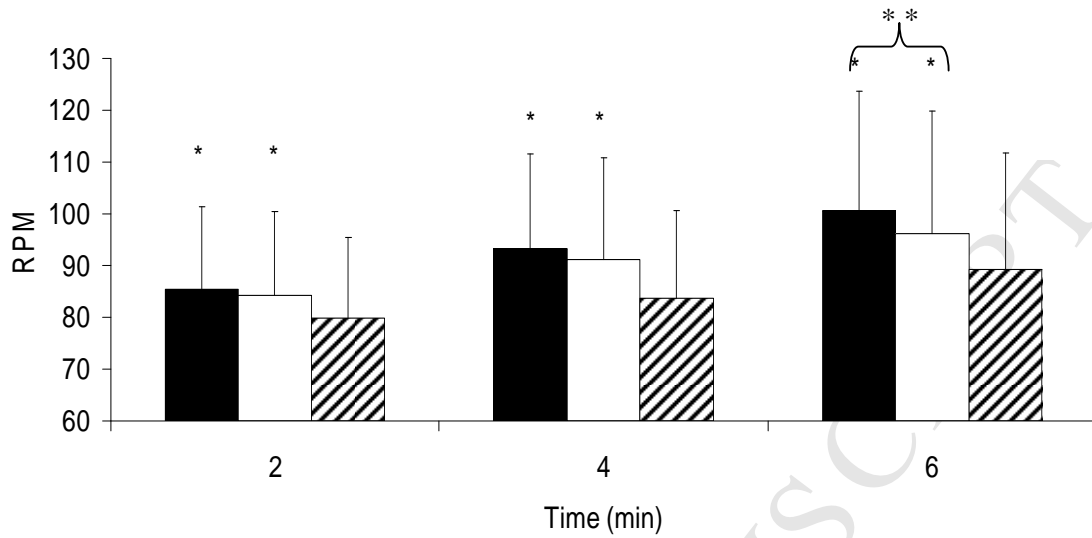
|    | Music condition | Pre-trial    | Post-trial   |
|----|-----------------|--------------|--------------|
| PA | Lyrics          | 15.48 (4.11) | 19.24 (4.07) |
|    | No lyrics       | 15.44 (3.97) | 19.56 (3.56) |
|    | No music        | 15.52 (3.08) | 18.40 (4.01) |
| NA | Lyrics          | 7.44 (2.96)  | 6.40 (2.10)  |
|    | No lyrics       | 7.56 (2.77)  | 6.16 (1.62)  |
|    | No music        | 7.72 (3.33)  | 6.28 (2.21)  |

Table 3

*Heart rate and RPE Responses (Means and Standard Deviations) at 2, 4, and 6 min while Cycling under Conditions of Lyrics, No Lyrics, and a No-music Control*

| Heart Rate (bpm) | 2 min          | 4 min          | 6 min          | Overall        |
|------------------|----------------|----------------|----------------|----------------|
| Lyrics           | 136.84 (14.37) | 141.64 (23.09) | 154.52 (19.24) | 140.20 (13.56) |
| No lyrics        | 139.00 (13.35) | 148.84 (17.43) | 154.40 (21.13) | 145.40 (15.26) |
| No music         | 136.77 (12.49) | 142.80 (14.63) | 144.52 (32.49) | 140.49 (14.03) |
| RPE              | 2 min          | 4 min          | 6 min          | Overall        |
| Lyrics           | 10.76 (1.98)   | 12.08 (1.89)   | 13.68 (2.11)   | 11.83 (1.66)   |
| No lyrics        | 10.72 (1.70)   | 12.36 (1.68)   | 13.68 (2.10)   | 11.84 (1.49)   |
| No music         | 11.16 (1.89)   | 12.52 (1.56)   | 13.96 (2.26)   | 12.16 (1.54)   |





*Figure 1.* Mean revolutions per minute (RPM) responses at each 2 min interval during the 6-min cycling trial for ML (black bar), NL (white bar) and NM (striped bar) conditions. T-bars represent standard deviation. \*Differs significantly ( $p = .006$ ) from NM condition. \*\*ML differs significantly ( $p = .010$ ) from NL.

**Highlights**

- Experimental assessment on the role of lyrics in exercise.
- Psychological, psychophysical, and physiological variables included.
- Musical accompaniment enhanced cycling cadence during submaximal cycle ergometry.
- The inclusion of lyrics enhanced cycling cadence towards the end of the task.
- Inclusion of lyrics had no effect on affect, perceived exertion, or heart rate.