

1 Running Head: MUSIC AND VIDEO DURING EXERCISE

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9 Can High-intensity Exercise be More Pleasant?

10 Attentional Dissociation using Music and Video

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12 Leighton Jones, Costas I. Karageorghis

13 School of Sport and Education, Brunel University London, UK

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15 Panteleimon Ekkekakis

16 Department of Kinesiology, Iowa State University, USA

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**Abstract**

Theories suggest that external stimuli (e.g., auditory and visual) may be rendered ineffective in modulating attention when exercise intensity is high. We examined the effects of music and parkland video footage on psychological measures during and after stationary cycling at two intensities: 10% of maximal capacity below ventilatory threshold and 5% above. Participants ( $N = 34$ ) were exposed to four conditions at each intensity: music-only, video-only, music-and-video, and control. Analyses revealed main effects of condition and exercise intensity for affective valence and perceived activation ( $p < .001$ ), state attention ( $p < .05$ ), and exercise enjoyment ( $p < .001$ ). The music-only and music-and-video conditions led to the highest valence and enjoyment scores during and after exercise regardless of intensity. Findings indicate that attentional manipulations can exert a salient influence on affect and enjoyment even at intensities slightly above ventilatory threshold.

**Keywords:** affect, attention, dual-mode theory, exercise enjoyment

1           One of the most compelling challenges for public health in the 21st century is finding  
2 effective ways to increase physical activity and decrease sedentary behavior (Biddle,  
3 O'Connor, & Braithwaite, 2011). After decades of concentrating on cognitive variables, such  
4 as self-efficacy, perceptions of benefits and barriers, and appraisals of social support as the  
5 main drivers of motivation for physical activity, researchers are now also beginning to  
6 consider the possible role of affective variables, such as pleasure and enjoyment (e.g.,  
7 Ekkekakis, Hargreaves, & Parfitt, 2013). Preliminary findings suggest that affective variables  
8 may be significant (e.g., Williams, Dunsiger, Jennings, & Marcus, 2012) or substantial (e.g.,  
9 Rhodes, Fiala, & Conner, 2009) predictors of physical activity. This has been acknowledged  
10 by the American College of Sports Medicine (2013), which states in the guidelines for  
11 exercise prescription that "...feelings of fatigue and negative affect ...can act as a deterrent to  
12 continued participation" (p. 374). Nonetheless, there is a paucity of evidence on how the  
13 affective experiences of participants might be improved. Music and video are two obvious  
14 targets for research into this important question, given their popularity among exercisers as a  
15 means by which to improve the overall affective experience of exercise.

16           Researchers often cite *attentional dissociation* as a cognitive mechanism underlying  
17 the psychological and ergogenic effects of music (e.g., Hutchinson et al., 2010; Karageorghis  
18 et al., 2013). This mechanism refers to the ability of music to draw attention externally and  
19 away from internal fatigue-related cues. Evidence shows that dissociation is linked with a  
20 more positive exercise experience (e.g., Karageorghis & Jones, 2014). When applied to  
21 exercise, the overload of attentional capacity associated with strenuous activity results in the  
22 availability of less processing capacity for environmental stimuli (e.g., processing of auditory  
23 and visual stimuli) and a reduction in performance (Rejeski, 1985; Tenenbaum, 2001). In  
24 contrast, the greater availability of attentional processing resources afforded by lower  
25 exercise intensities would presumably enable someone to attend to the aesthetic qualities of

1 auditory and visual stimuli available in the sensory array. By extension, it would seem  
2 reasonable to propose that this greater availability of processing capacity would also enable  
3 an exerciser to take fuller advantage of the *combination* of auditory and visual stimuli, as  
4 opposed to the aesthetic qualities of either type of sensory stimulus in isolation.

5 Tenenbaum's (2001) social-cognitive model of attention, which proposes a  
6 relationship between physical effort and attention allocation, and Rejeski's (1985) parallel  
7 processing model both posit that exercise intensity determines the extent to which an external  
8 stimulus such as music can inhibit the processing of other sensory cues. Specifically, both  
9 models propose that there is a level of intensity beyond which the ability of the exerciser to  
10 voluntarily shift the attentional focus to external cues (Tenenbaum) and actively regulate the  
11 perception of exertion (Rejeski) is inhibited. Beyond a critical level of intensity, the focus of  
12 attention automatically shifts internally and is no longer amenable to manipulation through  
13 cognitive techniques.

14 Evidence from the domain of neuroscience shows that visual cues dominate auditory  
15 cues in determining behavioral responses (e.g., Colavita, 1974; Koppen, Levitan, & Spence,  
16 2009). In line with Rejeski's (1985) model and the notion of limited attentional capacity, it is  
17 likely that visual stimuli, rather than auditory stimuli, are more effective when competing  
18 with internal cues for this limited capacity. Physical activity is unlikely to be conducted in the  
19 absence of other sensory information (e.g., a blindfold or noise-cancelling headphones [cf.  
20 Boutcher & Trenske, 1990]); therefore, if there is an increasing amount of internal, fatigue-  
21 related information received during physical activity, it is less likely that cues received from  
22 external senses (i.e., optic, auditory, tactile, olfactory, and gustatory) will make it through  
23 from preconscious to conscious processing.

24 External cues must compete with the increasing strength/amount of the internal  
25 sensations for conscious awareness, and it is logical to surmise that visual rather than

1 auditory stimuli would be more successful in this competition given the preference for visual  
2 stimuli when presented bimodally with other senses (Hartcher-O'Brien, Gallace, Krings,  
3 Koppen, & Spence, 2008; Koppen & Spence, 2007). It may be that visual stimuli have  
4 greater capacity to capture the attention of an individual during exercise and therefore distract  
5 them from internal, fatigue-related cues. In light of this, experimental designs comparing the  
6 efficacy of visual and auditory stimuli during exercise appear to be warranted.

7         The dual-mode theory (DMT; Ekkekakis, 2003) posits that affective responses during  
8 exercise are determined by the constant interplay between cognitive factors (appraisal of  
9 sensory information, shifts in attentional focus) and interoceptive factors (e.g., acidosis, rise  
10 in core temperature). The range of exercise intensity can be divided into three domains: First,  
11 below the ventilatory threshold (VT; i.e., the threshold intensity at which a larger volume of  
12 carbon dioxide is expelled than the volume of oxygen consumed), affective responses tend to  
13 be mostly positive and associated with cognitive factors. Second, at intensities proximal to  
14 VT when exercise begins to pose an appreciable challenge, affective responses tend to vary  
15 across individuals, with some reporting increases but others decreases in pleasure. This  
16 variability is presumed to reflect individual differences in the modulation of sensory  
17 information (e.g., tolerance), varying cognitive appraisals, and, importantly, differences in the  
18 use of cognitive methods for dealing with the challenge (e.g., attentional dissociation). Third,  
19 at intensities that no longer permit a physiological steady state (i.e., when heart rate, oxygen  
20 uptake, and blood lactate begin to rise inexorably), affective responses are homogeneously  
21 negative, strongly linked to physiological strain, and impervious to cognitive manipulation.  
22 Nonetheless, the shift toward negative affective responses as exercise intensity increases is  
23 immediately reversed upon cessation of exercise (Ekkekakis, Hall, & Petruzzello, 2008;  
24 Sheppard & Parfitt, 2008).

25

## 1 **Theory-based Empirical Research**

2           In studies addressing Tenenbaum's (2001) aforementioned social-cognitive model of  
3 attention, researchers have demonstrated that, as exercise intensity increases, there is a  
4 gradual shift from dissociative to associative focus (Connolly & Tenenbaum, 2010;  
5 Hutchinson & Tenenbaum, 2007). Similarly, studies incorporating measures of affect have  
6 demonstrated that the shift toward associative focus is accompanied by a decline in pleasure  
7 (e.g., Welch, Hulley, Ferguson, & Beauchamp, 2007). Studies that have specifically tested  
8 the postulates of the DMT have found that ratings of pleasure-displeasure exhibit a quadratic  
9 decline when the exercise intensity exceeds VT (Ekkekakis, Parfitt, & Petruzzello, 2011).  
10 Presumably, this is indicative of the rising influence of interoceptive cues. Accordingly,  
11 Ekkekakis (2003) reported negative correlations of increasing magnitude between ratings of  
12 pleasure-displeasure and physiological indices of intensity (e.g., oxygen uptake, respiratory  
13 exchange ratio, blood lactate).

## 14 **Auditory and Visual Stimuli during Exercise**

15           Music during exercise is often used in an *asynchronous* mode— this means that  
16 individuals make no conscious effort to synchronize their movements to the beat of the music  
17 (Karageorghis & Priest, 2012a). This application has been shown to have positive affective,  
18 psychophysical (i.e., reduced RPE), and motivational outcomes (e.g., Hutchinson &  
19 Karageorghis, 2013; Hutchinson et al., 2010; Karageorghis, Jones, & Stuart, 2008), which are  
20 more pronounced for women during more complex motor tasks (e.g. circuit-type exercises;  
21 Karageorghis et al., 2010). Such evidence, coupled with the ease of use, makes the  
22 application of asynchronous music during exercise a viable intervention. Karageorghis and  
23 Jones (2014) examined the effects of exercise intensity on attentional focus across conditions  
24 that included a range of music tempi (slow to very fast) and a no-music control. The findings  
25 were similar to those of Hutchinson and Tenenbaum (2007), as the attentional shift from

1 predominantly dissociative to associative thoughts occurred at ~69% of maximal heart rate  
2 reserve (maxHRR) when exercising without music. Nonetheless, a key finding of  
3 Karageorghis and Jones was that the attentional shift occurred at ~78% maxHRR during the  
4 fast-tempo condition (see Figure 1).

5 Both the auditory and visual environment in which people exercise is cited as playing  
6 an important role in affective responses to exercise and possibly the degree of adherence  
7 (e.g., Annesi, 2001; Karageorghis & Priest, 2012a, 2012b; Pretty, Peacock, Sellens, &  
8 Griffin, 2005). The stimuli in the visual environment can vary from narrow foci such as  
9 magazines and TV shows to broader foci such as the landscape. People generally consider  
10 exercise in a natural environment to be more attractive than exercise in an urban one (e.g.,  
11 Hartig & Staats, 2006), while several studies have shown that the aesthetic quality of the  
12 environment increases the amount of exercise done (e.g., Humpel, Owen, & Leslie 2002).  
13 The present study required the use of visual stimuli that were congruent with the nature of the  
14 exercise activity (cycling) and easily standardized; a rolling parkland scene was therefore  
15 deemed appropriate. Such “green exercise” has been associated with the concept of  
16 *restoration*, which entails psychological distance from a person’s usual routines and habitual  
17 focus of attention (Hartig & Staats, 2006).

18 The present study was predicated on the notion that a dissociative manipulation of  
19 attentional focus through music and video can delay the transition to the associative state  
20 during exercise. In turn, this effect was theorized to be reflected in subjective indices such as  
21 affect and enjoyment. Thus, the purpose was to examine the effects of external stimuli  
22 (asynchronous music and video footage of parkland) on psychological variables (affective  
23 valence, perceived activation, attentional focus, and enjoyment) at intensities 10% below VT  
24 and 5% above during stationary cycling. It was hypothesized ( $H_1$ ) that the music-and-video  
25 condition would lead to more pleasure, higher activation, more dissociative thoughts, and a

1 higher level of postexercise enjoyment compared to single-modality (music or video) and  
2 control conditions when exercising below VT. Second, it was hypothesized ( $H_2$ ) that the  
3 single-modality conditions would show differences on all dependent variables compared to  
4 control during exercise below VT. Third, it was hypothesized ( $H_3$ ) that the three experimental  
5 conditions (one combined and two single-modality conditions) would show differences on all  
6 dependent variables compared to the control condition when exercising above VT. Fourth, it  
7 was hypothesized ( $H_4$ ) that there would be differences between in-task and posttask affective  
8 responses across all conditions, with posttask responses being more positive than in-task  
9 responses.

## 10 Method

11 The study received approval from the first and second authors' institutional ethics  
12 committee and all participants provided written informed consent.

### 13 Stage 1 – Selection of Auditory and Visual Stimuli

14 **Music selection. *Participants and procedure.*** A sample of 153 ( $M_{\text{age}} = 19.5$  years,  
15  $SD = 1.6$  years) volunteer sports science students from Brunel University London were used  
16 to identify possible music selections for use in the experimental protocol (Stage 2). Given the  
17 personal factors that influence music preference, participants at each stage of the present  
18 study were similar in terms of age (18–25 years), race (Caucasian), and sociocultural  
19 background (spent their formative years in the UK; see Karageorghis & Terry, 1997).  
20 Participants were asked whether they had any form of hearing deficiency and none reported  
21 that they did.

22 Participants were asked to record their five favorite pieces of music for stationary  
23 cycling exercise. Subsequently, the selections were classified by tempo and 20 tracks of a  
24 similar tempo to that required for experimental testing (fast: 135 bpm; very fast: 139 bpm;  
25 see Karageorghis et al., 2011) were subjected to further assessment. A panel of 10



1 purposively selected sports science students ( $M_{\text{age}} = 20.9$  years,  $SD = 1.5$  years) rated the  
2 motivational qualities of the 20 tracks using the Brunel Music Rating Inventory-3  
3 (Karageorghis, 2008). This procedure was undertaken to ensure that music used in the  
4 experimental trials was homogenous in terms of its motivational qualities (lyrical  
5 affirmations, extra-musical associations, etc.), as a lack of homogeneity can present a threat  
6 to internal validity. The panel matched the profile (i.e., age and sociocultural background) of  
7 the intended participants in the experimental trials (see Karageorghis & Terry, 1997). The  
8 panel rated the motivational qualities of each track with reference to cycling at a moderate-to-  
9 high intensity (5 out of 10 on the Borg CR10 scale [Borg, 1998]). The final music selection  
10 followed qualitative guidelines stipulated by Karageorghis et al. (2006) in order to optimize  
11 the music selection procedure. The tempo of a track was digitally altered in instances where it  
12 was not an exact match of the required tempo. Four tracks (total duration, 10 min) with  
13 similar motivational quotients from each tempo were used in Stage 2 of the present study (see  
14 Table 1 for track details).

15 **Video selection. *Participants and procedure.*** A panel of 10 purposively selected  
16 sports science students ( $M_{\text{age}} = 21.2$  years,  $SD = 1.9$  years) from Brunel University London  
17 evaluated three pieces of video footage using a 5-point scale according to how well it  
18 represented a pleasant rural scene (not at all, slightly, moderately, strongly, or very strongly  
19 representative; Pretty et al., 2005). A criterion was set whereby 90% of the panel had to deem  
20 the footage to be at least “strongly representative”; this criterion was met for one video.  
21 Video filmed from a point-of-view (POV) perspective in a parkland setting was selected. The  
22 speed of the footage was adjusted slightly to ensure congruence between participants’  
23 cadence on the stationary cycle (75 rpm) and the changing environment in the video. The  
24 original video footage was edited to be 10 min in duration.

25

## 1 **Stage 2: Experimental Investigation**

2           **Power analysis.** A power analysis was conducted using G\*Power 3 (Faul, Erdfelder,  
3 Buchner, & Lang, 2009) based on a medium-to-large effect size for affective responses  
4 (Feeling Scale [Hardy & Rejeski, 1985] and Felt Arousal Scale [Svebak & Murgatroyd,  
5 1989]) for a Condition x Intensity interaction ( $\eta_p^2 = .10$ ; Hutchinson & Karageorghis, 2013,  
6 an alpha level of .05 and power at .80). This indicated that 32 participants would be required.  
7 An extra six participants were recruited to protect against attrition and deletions due to  
8 outliers. The independent variable of sex was not included in the power analysis given that it  
9 was included in the design for exploratory purposes and not involved in any of the research  
10 hypotheses.

11           **Participants.** Participants (19 women and 19 men;  $M_{\text{age}} = 21.1$  years,  $SD = 1.9$  years;  
12  $VO_{2\text{max}} M = 43.91$  ml/kg/min,  $SD = 7.75$  ml/kg/min; women  $VO_{2\text{max}} M = 41.26$  ml/kg/min,  
13  $SD = 7.75$  ml/kg/min; men  $VO_{2\text{max}} M = 47.26$  ml/kg/min,  $SD = 8.08$  ml/kg/min) were  
14 moderately physically active, which was defined as engaging in moderate-intensity (60–75%  
15  $VO_{2\text{max}}$  [maximal aerobic capacity]) aerobic exercise for a minimum of 30 min at least three  
16 times a week over the previous 6 months (cf. Hutchinson & Tenenbaum, 2007).

17           **Apparatus and measures.** An electronically-braked cycle ergometer (Velotron  
18 Dynafit Pro) was used for testing along with a wall-mounted stereo system (Tascam CD-  
19 A500) and a decibel meter (GA 102 Sound Level Meter Type 1) to standardize music  
20 intensity at 75 dbA. This sound intensity is advised by the UK Health and Safety Executive  
21 as below the need for individuals to wear ear protection (The Control of Noise at Work  
22 Regulations, 2005). Video footage was played using a desktop computer connected to a  
23 projector (Mitsubishi LCD Projector XL9U). A projection screen (195 cm x 280 cm) was  
24 situated 250 cm in front of the participant and the video images were projected onto it.

1           Affective valence (pleasure-displeasure) and perceived activation were assessed in-  
2 task and immediately posttask using the Feeling Scale (FS; Hardy & Rejeski, 1989) and Felt  
3 Arousal Scale (FAS; Svebak & Murgatroyd, 1985), respectively. The Feeling Scale (Hardy &  
4 Rejeski) is a single-item, 11-point scale that ranges from +5 (*very good*) to -5 (*very bad*). The  
5 FAS (Svebak & Murgatroyd, 1985) is a single-item 6-point scale that ranges from 1 (*low*  
6 *arousal*) to 6 (*high arousal*). In-task measures were taken at Minutes 4 and 8 during each 10-  
7 min condition. Attentional focus was assessed using Tammen's (1996) single-item Attention  
8 Scale, which is a bipolar scale attached to the verbal anchors "Internal focus (bodily  
9 sensations, heart rate, breathing, etc.)" and "External focus (daydreaming, external  
10 environment, etc)". Participants were required to mark the scale, which was 20 cm in length  
11 (the original scale was 10 cm in length), with an "X" to indicate their predominant focus  
12 during the exercise bout and the level of internal or external focus was ascertained through  
13 measuring the distance from the left-hand point of the scale to the "X" in centimeters. The  
14 number was multiplied by 5 to give a score out of 100, with scores over 50 indicating a  
15 predominantly external focus.

16           The Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991) was  
17 administered immediately after each condition. PACES comprises 18 items attached to a 7-  
18 point bipolar scale (e.g., I dislike it – I like it) and respondents are given the instruction "Rate  
19 how you feel at the moment about the physical activity you have been doing". Higher PACES  
20 scores reflect greater levels of enjoyment. Music preference for each of the conditions in  
21 which music was used was assessed using a single item: "Based on how you feel right now,  
22 rate how much you like the music" with responses provided on a 10-point Likert scale  
23 anchored by 1 ("I do not like it at all") and 10 ("I like it very much"; Karageorghis & Jones,  
24 2014).

1           **Pretest and habituation.** Participants completed a ramp protocol on a stationary  
2 cycle to establish their  $\text{VO}_2\text{max}$  and VT. The test was terminated at the point of volitional  
3 exhaustion and maximal oxygen uptake was verified using standard criteria (American  
4 College of Sports Medicine, 2013). The highest level of oxygen uptake averaged over 20 s  
5 was designated as  $\text{VO}_2\text{max}$ . VT was identified offline using software (Ekkekakis, Lind, Hall,  
6 & Petruzzello, 2008) based on the three-method procedure described by Gaskill et al. (2001).  
7 A habituation session followed the pretest and each participant was familiarized with the  
8 experimental protocol and afforded an opportunity to ask questions.

9           Participants cycled at 10% of maximum capacity below VT and 5% of maximum  
10 capacity above during the experimental trials. Pilot testing indicated that participants were  
11 generally unable to maintain exercise for the necessary duration at 10% above VT owing to  
12 localized muscle fatigue.

13           **Experimental trial.** There were three experimental conditions (music-only, video-  
14 only, and music-and-video) and one control condition (no music and visually sterile) at 10%  
15 of maximum capacity below VT and 5% above (eight conditions in total). In the music-only  
16 condition, participants were exposed to a 10-min playlist while immersed in a visually sterile  
17 environment. In the video-only condition, participants were exposed to a 10-min video  
18 showing point of view (POV) footage recorded in a parkland setting from a cycle route and  
19 there was no audio accompaniment (i.e., sounds of the parkland environment) to the footage.  
20 In the music-and-video condition, each participant was exposed to a 10-min music playlist  
21 and observed the POV video footage. In the control condition, participants were exposed to  
22 neither music nor video footage; however, in the interest of ecological validity, the eyes and  
23 ears were not occluded.

24           Participants wore a heart rate monitor when they entered the laboratory for each  
25 session. Following a 2-min rest period, heart rate was recorded and used as a resting value.

1 Each participant was then given an opportunity to stretch before each trial, which began with  
2 a warm-up ( $75 \pm 3$  rpm for 5 min). The ergometer was then set at the appropriate resistance  
3 (Watts) to correspond with either 10% of maximum capacity below VT or 5% above.  
4 Cadence was standardized at  $75 \pm 3$  rpm to prevent auditory-motor synchronization with  
5 music tempo (135 bpm or 139 bpm).

6 Each participant was administered the FS and FAS after 4 and 8 min of each  
7 condition. At 10 s before the end of each condition that included music, participants were  
8 asked to rate their collective preference for the music selections they had just heard. Upon  
9 completion of each condition, the researcher lowered the wattage on the cycle ergometer to  
10 zero and the participant dismounted to complete the posttask measures (attentional focus  
11 item, FS, FAS, and PACES) while seated at a nearby desk. Posttask measures were  
12 completed within 2 min of exercise cessation.

13 Two conditions separated by a rest period were administered during each testing  
14 session. Participants were required to complete questionnaires after the first condition and  
15 then to rest until their heart rate returned to within 10% of their resting value, at which point  
16 they would rest for a further 2 min before commencing the second condition. The order of  
17 conditions was randomized to minimize potential order and learning effects. Each testing  
18 session included one condition at 5% above VT and one at 10% below VT. The rest period in  
19 between conditions was approximately 10 min. It was not possible to fully counterbalance the  
20 design (between and within conditions; Harris, 2008, p. 136) as there was an insufficient  
21 number of participants (40,320 participants would have been required). Each participant  
22 visited the laboratory on five occasions (one pretest and habituation, and four testing  
23 sessions) and each session lasted no longer than 40 min. Participants were requested to follow  
24 similar patterns of activity (including no vigorous physical activity) and diet on the day  
25 before and of each experimental trial (Harris, 2008, p. 134). Each participant engaged in the

1 trials individually. The experimental trials were scheduled at the same time of day for each  
2 participant over a 4-week period, with a minimum of 3 days between each trial. With the  
3 inclusion of the pretest, each participant visited the laboratory on five occasions.

#### 4 **Data Analysis**

5 Data were screened for univariate outliers using  $z$ -scores  $> \pm 3.29$  and multivariate  
6 outliers using the Mahalanobis distance test with  $p < .001$ , as well as examined for the  
7 parametric assumptions that underlie mixed-model  $4 \times 2 \times 2$  (Condition  $\times$  Exercise Intensity  $\times$   
8 Sex) ANOVA and MANOVA. Affective variables (in-task and posttask FS and FAS) were  
9 assessed using a MANOVA while attentional focus and exercise enjoyment (PACES) were  
10 assessed using ANOVA. Music preference ratings were employed as a manipulation check  
11 and were analyzed using a  $2 \times 2$  (Condition  $\times$  Exercise Intensity) ANOVA. Omnibus  
12 statistics were followed by  $F$  tests that were Greenhouse-Geisser adjusted where necessary,  
13 and these were followed by Bonferroni-adjusted pairwise comparisons or checks of standard  
14 errors. Partial eta squared ( $\eta_p^2$ ) was the effect size statistic of choice and its value multiplied  
15 by 100 denotes the percentage variance in the dependent variable(s) that can be attributed to  
16 the independent variable manipulation (Tabachnick & Fidell, 2013, p. 223). To explore  
17 whether state attention was associated with in-task affective valence, Pearson's product  
18 moment correlations were computed. For all analyses, significance was accepted at  $p < .05$   
19 and exact  $p$  is reported other than when  $p < .001$ .

#### 20 **Results**

21 Four male participants did not complete the protocol and thus are not included in the  
22 analyses presented herein. Prior to the main analyses, univariate outlier tests revealed 11  
23 outliers that were suitably adjusted (see Tabachnick & Fidell, 2013, p. 77). There were no  
24 multivariate outliers. Tests of the distributional properties of the data in each cell of the  
25 analysis revealed violations of normality in three of the 100 cells (all at  $p < .05$ ). Tabachnick

1 and Fidell (2013, pp. 78–79) suggest that the  $F$  test is sufficiently robust to withstand such  
2 minor violation of normality. Collectively, the diagnostic tests indicated that the assumptions  
3 underlying MANOVA and ANOVA were satisfactorily met. In the interests of parsimony,  
4 only omnibus and post hoc analyses are presented herein (the step-down tests are available  
5 from the corresponding author).

### 6 **Manipulation Check**

7       The manipulation check for music preference ratings revealed no Condition x  
8 Intensity interaction,  $F(1, 33) = .10, p = .752, \eta_p^2 = .00$ . There was no main effect for  
9 condition,  $F(1, 33) = .02, p = .889, \eta_p^2 = .00$ , but there was a main effect for intensity,  $F(1,$   
10  $33) = 7.69, p = .009, \eta_p^2 = .19$ , showing that participants generally preferred music at the low  
11 intensity. The manipulation check for heart rate revealed a significant difference between the  
12 10% below VT and 5% above intensities;  $t(33) = 15.95, p < .001$ . The mean heart rate  
13 recorded during the 10% below VT conditions was 131.87 bpm ( $SD = 13.47$  bpm), compared  
14 against  $M = 150.44$  bpm ( $SD = 12.06$  bpm) for conditions 5% above VT. The highest mean  
15 heart rate was recorded during the above VT combined music-and-video condition ( $M =$   
16  $152.14$  bpm,  $SD = 13.94$  bpm), while the lowest was recorded for the below VT video-only  
17 condition ( $M = 128.71$  bpm,  $SD = 15.67$ ).

### 18 **Affective Variables**

19       There were no interaction effects for the affective variables (see Table 2). There were,  
20 however, significant main effects for condition and intensity (see Table 2 and Figure 2).  
21 Pairwise comparisons for in-task affective valence indicated that the music-only and music-  
22 and-video conditions differed from both the video-only (95% CI = 0.60–1.49,  $p < .001$ ; 95%  
23 CI = 0.55–1.38,  $p < .001$ ) and control conditions (95% CI = 1.01–2.15,  $p < .001$ ; 95% CI =  
24 1.08–1.91,  $p < .001$ ). Moreover, the video-only condition differed from control (95% CI .09–  
25 .98,  $p = .012$ ). Pairwise comparisons for posttask affective valence revealed that the music-

1 only and music-and-video conditions differed from both the video-only condition (95% CI =  
 2 0.72–2.00,  $p < .001$ ; 95% CI = 0.61–1.82,  $p < .001$ ), and the control condition (95% CI =  
 3 1.09–2.34,  $p < .001$ ; 95% CI = 1.00–2.12,  $p < .001$ ). Pairwise comparisons indicated that in-  
 4 task affective valence was more positive at 10% below VT than it was at 5% above (95% CI  
 5 = 0.90–1.71,  $p < .001$ ), and posttask valence demonstrated an identical trend (95% CI = 1.13–  
 6 2.14,  $p < .001$ ). Pairwise comparisons for in-task perceived activation indicated that the  
 7 music-only and the music-and-video conditions yielded higher levels of activation than the  
 8 video-only (95% CI = 0.35–1.07,  $p < .001$ ; 95% CI = 0.43–1.08,  $p < .001$ ) and control  
 9 conditions (95% CI = 0.50–1.46,  $p < .001$ ; 95% CI = 0.58–1.47,  $p < .001$ ). The posttask  
 10 perceived activation measures indicated an identical trend: music-only and music-and-video  
 11 conditions elicited higher levels of activation than the video-only (95% CI = 0.35–1.385,  $p <$   
 12  $.001$ ; 95% CI = 0.47–1.38,  $p < .001$ ) and control conditions (95% CI = 0.72–1.75,  $p < .001$ ;  
 13 95% CI = 0.87–1.72,  $p < .001$ ). The video-only condition also elicited higher levels of  
 14 activation than the control condition (95% CI = 0.06–0.67,  $p = .011$ ). Means and standard  
 15 deviations are presented in Table 3.

### 16 **State Attention**

17 There were no interaction effects for state attention (see Table 2). There were  
 18 significant main effects for condition and intensity (see Table 2 and Figure 3). Pairwise  
 19 comparisons for state attention indicated that the music-and-video condition promoted more  
 20 dissociative thoughts than the remaining three conditions ( $p < .05$ ). Pairwise comparisons  
 21 also revealed more dissociative thoughts in the 10% below VT condition than the 5% above  
 22 condition (95% CI = 17.70–32.39,  $p < .001$ ). Means and standard deviations are presented in  
 23 Table 3.

### 24 **Enjoyment**

25 There were no interaction effects for PACES (see Table 2). There were significant  
 26 main effects for condition and intensity (see Table 2). Pairwise comparisons indicated that



1 participants experienced greater exercise enjoyment in the music-only condition and music-  
2 and-video conditions when compared to the video-only (95% CI = 6.02–22.62,  $p < .001$ ; 95%  
3 CI = 6.44–21.33,  $p < .001$ ) and control conditions (95% CI = 11.45–27.16,  $p < .001$ ; 95% CI  
4 = 11.33–26.40,  $p < .001$ ). Pairwise comparisons also indicated that participants experienced  
5 greater enjoyment at 10% below VT when compared to 5% above (95% CI = 3.63–10.90,  $p <$   
6  $.001$ ). Means and standard deviations are presented in Table 3.

### 7 **Correlations between State Attention and In-task Affective Valence**

8 Dissociative thoughts (assessed postexercise) were positively correlated with affective  
9 valence during exercise above VT, when the attentional focus manipulations are theorized to  
10 be influential (music-only,  $r = .40$ ,  $p = .018$ ; music-and-video,  $r = .53$ ,  $p = .001$ ; video-only,  $r$   
11  $= .40$ ,  $p = .019$ ). Conversely, the correlations were nonsignificant below the threshold, when  
12 the challenge was presumably minimal (music-only,  $r = .15$ ; music-and-video,  $r = .29$ ; video-  
13 only,  $r = .12$ ; all  $ps > .05$ ), or during the control conditions, when manipulations were absent  
14 (below threshold,  $r = -.03$ ; above threshold,  $r = .28$ ,  $ps > .05$ ).

### 15 **Discussion**

16 The main purpose of this study was to explore the effects of auditory and visual  
17 stimuli on a range of affective, attentional, and enjoyment measures during stationary cycling  
18 10% below and 5% above the VT. We predicted that combined music-and-video would lead  
19 to more positive outcomes than the single-modality (music or video) and control conditions  
20 when exercising below VT ( $H_1$ ). Moreover, we predicted that the single stimulus conditions  
21 would lead to more positive outcomes compared to control ( $H_2$ ). The music-only and music-  
22 and-video conditions exhibited the highest scores for affective valence and this finding  
23 provides partial support for the first and second research hypotheses. The hypothesis that the  
24 music-and-video condition would yield the most positive affective valence responses ( $H_1$ ) is  
25 not supported by the present data, given that it does not differ from the music-only condition.

1 The prediction that the music-only and video-only conditions would differ from control was  
2 realized, thus partially supporting  $H_2$ . In partial support of  $H_3$ , it appears that participants  
3 derived just as much affective benefit from music-and-video and music-only during the above  
4 VT condition, but video-only did not differ from control.

5 A similar pattern of findings was replicated in the perceived activation variable. The  
6 increased physiological load between the exercise intensities did not lead to higher scores on  
7 the FAS, although there was a difference in these scores across distraction conditions.  
8 Specifically, the higher scores reported in the music-only and the music-and-video conditions  
9 compared to video-only and control conditions may indicate that participants were using the  
10 FAS to indicate predominantly psychological activation rather than physiological arousal, as  
11 there were differences by condition but not by exercise intensity. Further, it is plausible that  
12 the video-only condition did not offer sufficient stimulation; there may have been a mismatch  
13 between the level of situation-demanded activation (high) and the stimulative qualities of the  
14 video (low).

15 It was expected that in-task affective responses would be significantly different to  
16 posttask but this difference did not emerge ( $H_4$ ). The lack of difference between the in-task  
17 and posttask measures of affective valence and activation may be a product of the way in  
18 which the data were treated. In-task measures were taken at Minutes 4 and 8 in each  
19 condition but were aggregated to minimize participants' possible negative response to a  
20 particular piece of music or, to a far lesser degree, a specific section of the video (see  
21 Karageorghis et al., 2011). The findings of the present study appear to depart from those of  
22 previous studies in terms of finding a difference between in-task and posttask affective  
23 valence (e.g., Ekkekakis et al., 2008; Sheppard & Parfitt, 2008). This is because previous  
24 studies have included a Condition x Time analysis, whereas the present study did not. In  
25 accordance with the DMT (Ekkekakis, 2003), there is a quadratic decline in affective valence

1 over time when exercising above VT but the present design did not account for such a time-  
2 dependent decline and thus minimized the magnitude of the affective decline by taking an  
3 average of the values at the two in-task time points.

4         The state attention data indicate that combined music-and-video elicited the highest  
5 number of dissociative thoughts at both exercise intensities, offering support for  $H_1$  (see  
6 Figure 3). Contrary to the research hypotheses ( $H_2$  and  $H_3$ ), the music-only and video-only  
7 conditions did not differ from control at either intensity. Moreover, the expected Condition x  
8 Intensity interaction did not emerge, showing that the two levels of exercise intensity had no  
9 moderating influence on attentional focus across the four conditions. As expected, there was  
10 a strong tendency toward association at the high exercise intensity with a mean difference of  
11 26 units (scale range: 0–100) between the low and high exercise intensities, and this latter  
12 finding mirrors those of related studies (e.g., Hutchinson & Tenenbaum, 2007; Karageorghis  
13 & Jones, 2014). It is noteworthy, however, that a consistent pattern of correlations  
14 demonstrated that the degree to which participants were able to dissociate was correlated with  
15 more positive affective responses at the above-threshold intensity. The significant  
16 correlations offer support for the DMT (Ekkekakis, 2003) owing to the positive influence of  
17 the interventions at the higher exercise intensity. According to DMT, cognitive manipulations  
18 have a low-to-moderate influence below VT but a strong influence at intensities proximal to  
19 VT. The significant correlations indicate that during exercise above VT, the more an  
20 exerciser is able to dissociate, the more pleasant s/he is likely to feel. This finding perhaps  
21 seems intuitive but does not have a strong empirical basis to date (Lind, Welch, & Ekkekakis,  
22 2009).

23         The PACES findings exhibited an identical pattern to those of posttask affective  
24 valence; at both exercise intensities, participants derived the greatest enjoyment in the music-  
25 only and music-and-video conditions. Interestingly, the manipulation check indicated that

1 music was preferred to a greater degree at the intensity below VT when compared to the  
2 intensity above VT ( $M_{\text{diff}} = .79$ ).

3       Taken collectively, the present findings highlight the utility of music and combined  
4 music-and-video stimuli as a means by which to enhance the affective responses of  
5 recreational exercise participants. These positive effects amplify those found in previous  
6 related studies (e.g., Annesi, 2001; Barwood, Weston, Thelwell, & Page, 2009). A pattern  
7 that emerged in the findings pertains to the nondifferentiation between music-only and music-  
8 and-video in terms of the range of dependent measures that were examined and that, contrary  
9 to the research hypothesis ( $H_1$ ), exercise intensity did not moderate the benefits that  
10 participants derived from the experimental manipulations. Ostensibly, the application of  
11 music-only and music-and-video was equally effective at exercise intensities of 10% below  
12 and 5% above VT. Theoretically, there is less information processing capacity available for  
13 environmental stimuli during strenuous exercise (cf. Rejeski, 1985; Tenenbaum, 2001), such  
14 as the stimuli employed in the present experimental conditions. Nonetheless, the relatively  
15 passive nature of music listening and watching video images renders these specific secondary  
16 tasks effective in enhancing the exercise experience.

17       What does appear to be slightly surprising is the relative ineffectiveness of the video-  
18 only condition. With the exception of in-task affect ( $M_{\text{diff}} = .53$ ), exposure to this condition  
19 did not enhance participants' responses relative to control. This finding might suggest that  
20 visual images of the sort employed here (pleasant parkland) do not tap the sensory pathways  
21 to the same degree as when used in combination with music (e.g., music-and-video vs.  
22 control;  $M_{\text{diff}} = 1.50$ ). An alternative explanation concerns the unfamiliar nature of viewing  
23 parkland footage without an accompanying soundtrack. If comparable tasks had been  
24 conducted in an outdoor environment with auditory deprivation, it would be interesting to  
25 gauge how the presence of similar visual stimuli would influence participants' responses.

1 Further, the music was selected owing to its motivational qualities for an exercise context  
2 whereas the video was not selected with such qualities in mind, as there is no comparable  
3 guiding framework to draw upon. The parkland video footage was selected with the premise  
4 that it would confer psychological benefits (cf. Pretty et al., 2005), but there may have been  
5 some disparity between the motivational qualities of the music and that of the video.

## 6 **Theoretical and Practical Implications**

7 From a theoretical standpoint, these results illustrate the efficacy of experimental  
8 manipulations pertaining to components of the information-processing system—specifically,  
9 attentional focus—in influencing affective responses. Moreover, the effect of these  
10 experimental manipulations was shown to be significant during exercise 5% above VT; an  
11 intensity that is capable of inducing a decline in affect (as shown in the above-threshold  
12 control condition). The role of attentional focus was evidenced in the significant correlations  
13 between dissociation and affective valence during exercise above VT. Accordingly, the  
14 present findings extend previous findings in the exercise domain concerning the efficacy of  
15 attention-related interventions in the amelioration of negative affect (Ochsner & Gross,  
16 2005).

17 It has been suggested that during the early stages of participation, physical activity is  
18 “...unlikely to be construed as inherently pleasurable or enjoyable” (Wilson, Rodgers,  
19 Blanchard, & Gessell, 2003, p. 2375). This is recognized as one of the major barriers to  
20 exercise initiation and adherence (American College of Sports Medicine, 2013). Set against  
21 this background, the present results have salient translational implications. Although the  
22 exact determination of the VT requires costly equipment that is not easily accessible to  
23 practitioners, the exercise prescription guidelines of the American College of Sports  
24 Medicine (2013) indicate that the threshold can be inferred by such markers as a noticeable  
25 decline in pleasure and the inability to maintain a conversation without panting. The present

1 results demonstrate that, even when the intensity reaches this level, the decline in pleasure  
2 may not be entirely unavoidable, as it can be meaningfully tempered by the use of music and  
3 the combined use of music and video.

4 From a practical perspective, these results present exercise professionals, for the first  
5 time, with evidence-supported and easily implementable options for ameliorating the  
6 affective experiences of individuals who find themselves exercising slightly above VT. This  
7 is a common occurrence in field settings, particularly among individuals who are beginning  
8 to exercise after prolonged periods of sedentariness. The implications of this finding for  
9 public health are evidenced in the proliferating data on the role of during-exercise affect  
10 (Williams et al., 2012) and enjoyment (Rhodes et al., 2009) in promoting exercise behavior.  
11 Although other techniques (e.g., cognitive reframing, imaging) may be shown to be effective  
12 in future research, music-alone and music-and-video interventions have the relative  
13 advantage of requiring no prior training before they can yield meaningful benefits.

#### 14 **Strengths and Limitations**

15 An original contribution of this work lies in the examination of the interactive effects  
16 of music and video at two exercise intensities related to the physiological marker of VT.  
17 Distraction techniques such as the combination of music and video are commonly found in  
18 the exercise domain but have received scant attention from researchers to date. Unlike most  
19 previous work (e.g., Nethery, 2002; Szmedra & Bacharach, 1998; Tenenbaum et al., 2004),  
20 the present study included a calculation of each participant's VT to establish a work rate  
21 corresponding with values 5% above and 10% below. This represents an advance from  
22 employing heart rate as a marker of exercise intensity and ensures a more accurate  
23 assignment of equal physiological load across participants. The stringent attempt to  
24 "homogenize" the qualities of the music in order to preserve internal validity also represents a  
25 strength of the current study.

1           The distractive stimuli that we employed consisted of motivational music (auditory)  
2 and video footage of parkland (visual). Clearly the music had motivational qualities whereas  
3 the video footage did not; rather the footage was compiled to represent “a pleasant rural  
4 scene”. We did not have a conceptual framework to facilitate the compilation of motivational  
5 video footage for exercise (as we did with music), and so sought a visual distraction that  
6 would be in keeping with the common experiences of exercisers and thus hold a degree of  
7 ecological validity. It is plausible that the use of a video with strong motivational qualities  
8 may have influenced the results differently, although the combination of such a video with a  
9 music program would have proven problematic from a methodological standpoint (cf. Loizou  
10 & Karageorghis, 2009).

11           Despite efforts to create an immersive environment in the laboratory, it was not  
12 possible to replicate the sensations associated with a real-life parkland environment (with the  
13 breeze in one’s face, the warmth of the sun, the sound of birdsong, etc.). The efficacy of  
14 exercising outdoors versus indoors has been established in the literature (e.g., Hug et al.,  
15 2009), but it is not possible to delineate the efficacy of the visual or auditory outdoor  
16 environment independently and it is likely that exercising in an outdoor environment as a  
17 holistic experience is responsible for its efficacy; the removal of one or other stimulus  
18 potentially limits the appeal of outdoor exercise.

19           The present sample comprised young adults who were moderately active and thus the  
20 findings cannot be generalized to the wider population without replication using a more  
21 broadly representative demographic. It was the noticeable dearth of experimental data  
22 pertaining to in-task interventions that contributed to the decision to employ a sample of  
23 active young adults. This approach represents the first step in examining the efficacy of such  
24 in-task interventions at moderate and high exercise intensities prior to extending the  
25 interventions to wider populations (e.g., older adults, cardiac rehabilitation patients).

## 1 **Future Directions**

2 Future research along this line will proceed in several directions, driven by practical,  
3 methodological, and theoretical questions. From a practical standpoint, one direction that was  
4 alluded to here involves the exploration of the degree of immersion that is required to  
5 optimize the effects of audiovisual stimuli on pleasure. For example, what types of video  
6 material are more effective? Is there a difference between methods that vary in the extent of  
7 immersion (e.g., speakers versus headphones; screens vs. virtual reality goggles)? What are  
8 the effects of imposed versus self-selected music? How do the characteristics of music (e.g.,  
9 volume, tempo) interact with exercise intensity in influencing the affective experience of  
10 exercise? From a methodological standpoint, future studies will involve a broader range of  
11 exercise intensities than the two examined here. For example, initially, graded exercise tests,  
12 in which intensity is continuously increased until the point of volitional fatigue, can be used  
13 to examine the effects of music across the entire range of intensity (cf. Karageorghis & Jones,  
14 2014). Finally, from a theoretical standpoint, future studies will combine audiovisual  
15 stimulation with an exploration of brain mechanisms via the use of non-invasive methods that  
16 are resistant to movement artifacts, such as near-infrared spectroscopy (Ekkekakis, 2009;  
17 Tempest & Parfitt, 2013).

## 18 **Conclusions**

19 The present findings demonstrate that music and music combined with video can  
20 significantly enhance the affective experience of exercise. This phenomenon appears robust,  
21 as it manifested across the spectrum of dependent variables, including more positive ratings  
22 of affective valence, higher perceived activation, and higher postexercise enjoyment scores.  
23 Furthermore, a finding of particular importance from both a theoretical and an applied  
24 perspective is that these manipulations maintained their effectiveness not only below VT, but  
25 also at an intensity 5% above.

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1 Table 1

2 *Details of Music Selections used in Experimental Conditions*

Experimental music selections				
Fast tempo tracks (135 bpm)				
Artist	Rihanna ft Calvin Harris	Chris Brown ft Benny Benassi	Avicci	Example
Track title	We Found Love	Beautiful People	Levels	Kickstarts
Album	Talk That Talk	F.A.M.E.	—	Won't Go Quietly
Credit	Def Jam	Jive	Universal	Data
BMRI-3 Score ( <i>M</i> )	31.1	32.0	30.9	31.0
Very fast tempo tracks (139 bpm)				
Artist	Darude	Bingo Players	Redlight	Redlight
Track title	Sandstorm	Rattle	Lost in Your Love	Get Out My Head
Album	Before the Storm	Around the Town	—	—
Credit	16 Inch	Hysteria	Polydor	Mercury Records
BMRI-3 Score ( <i>M</i> )	29.4	29.0	26.9	26.0

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1 Table 2  
 2 *Inferential Statistics Results for all Dependent Variables*

	Pillai's Trace	<i>F</i>	<i>df</i>	<i>p</i>	$\eta_p^2$
<b>Interaction effects</b>					
Affective variables					
Condition x Exercise Intensity x Sex	.16	1.31	12, 285	.213	.05
Condition x Exercise Intensity	.13	1.10	12, 285	.358	.04
Condition x Sex	.10	.79	12, 285	.660	.03
Exercise Intensity x Sex	.14	1.18	4, 29	.343	.14
State attention					
Condition x Exercise Intensity x Sex	—	.67	3, 96	.573	.02
Condition x Exercise Intensity	—	.33	3, 96	.807	.02
Condition x Sex	—	.48	3, 96	.699	.02
Exercise Intensity x Sex	—	.86	1, 96	.362	.03
Enjoyment					
Condition x Exercise Intensity x Sex	—	.19	3, 96	.906	.01
Condition x Exercise Intensity	—	.85	6, 192	.530	.03
Condition x Sex	—	1.18	3, 96	.323	.04
Exercise Intensity x Sex	—	.06	1, 32	.804	.00
<b>Main Effects</b>					
Affective variables					
Condition	.69	7.10	12, 285	.000	.23
Intensity	.62	11.75	4, 29	.000	.62
Sex	—	.04	1, 2	.853	.00



State attention

Condition	—	3.45	3, 96	.027	.10
Intensity	—	48.24	1, 32	.000	.60
Sex	—	.67	1, 32	.419	.02

Enjoyment

Condition	—	28.80	3, 96	.000	.47
Intensity	—	16.58	1, 32	.000	.34
Sex	—	1.28	1, 32	.266	.04

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1 *Table 3*

2 Descriptive Statistics for In-task and Posttask Measures (*N* = 34)

3

Condition	Exercise Intensity				Cohen's <i>d</i>
	Below VT		Above VT		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Music					
Feeling Scale (in-task)	2.85	1.21	1.85	1.64	0.81
Felt Arousal Scale (in-task)	3.97	0.82	4.21	0.82	0.33
Feeling Scale (post-task)	3.12	1.27	1.79	2.17	0.92
Felt Arousal Scale (post-task)	4.18	1.00	4.32	0.81	0.18
State Attention	66.66	21.32	39.57	23.26	1.21
PACES	94.24	14.57	88.24	17.37	0.37
Music and Video					
Feeling Scale (in-task)	2.91	1.29	1.60	1.75	1.00
Felt Arousal Scale (in-task)	4.24	0.75	4.03	0.87	0.30
Feeling Scale (post-task)	3.18	1.14	1.41	2.38	1.12
Felt Arousal Scale (post-task)	4.44	0.93	4.18	0.87	0.34
State Attention	73.18	18.68	47.07	27.00	1.12
PACES	95.32	14.20	85.74	20.99	0.53
Video					
Feeling Scale (in-task)	2.06	1.63	0.56	1.69	1.02
Felt Arousal Scale (in-task)	3.32	0.96	3.41	0.97	0.10
Feeling Scale (post-task)	1.88	1.93	0.32	2.00	0.88
Felt Arousal Scale (post-task)	3.29	1.06	3.44	1.31	0.14
State Attention	62.19	25.60	41.88	27.04	0.77
PACES	78.38	20.17	74.41	19.56	0.20
Control					
Feeling Scale (in-task)	1.38	1.59	0.16	2.08	0.71
Felt Arousal Scale (in-task)	2.93	1.23	3.25	1.31	0.27
Feeling Scale (post-task)	1.56	1.78	-0.12	2.61	0.86
Felt Arousal Scale (post-task)	2.94	1.15	3.03	1.24	0.08
State Attention	59.81	26.96	34.69	28.47	0.91
PACES	76.32	18.53	66.62	22.08	0.48

37 *Note.* Scores from females and males have been aggregated. The in-task measures recorded at

38 Minutes 4 and 8 have been averaged and are presented under the “in-task” heading. VT,

39 ventilator threshold.

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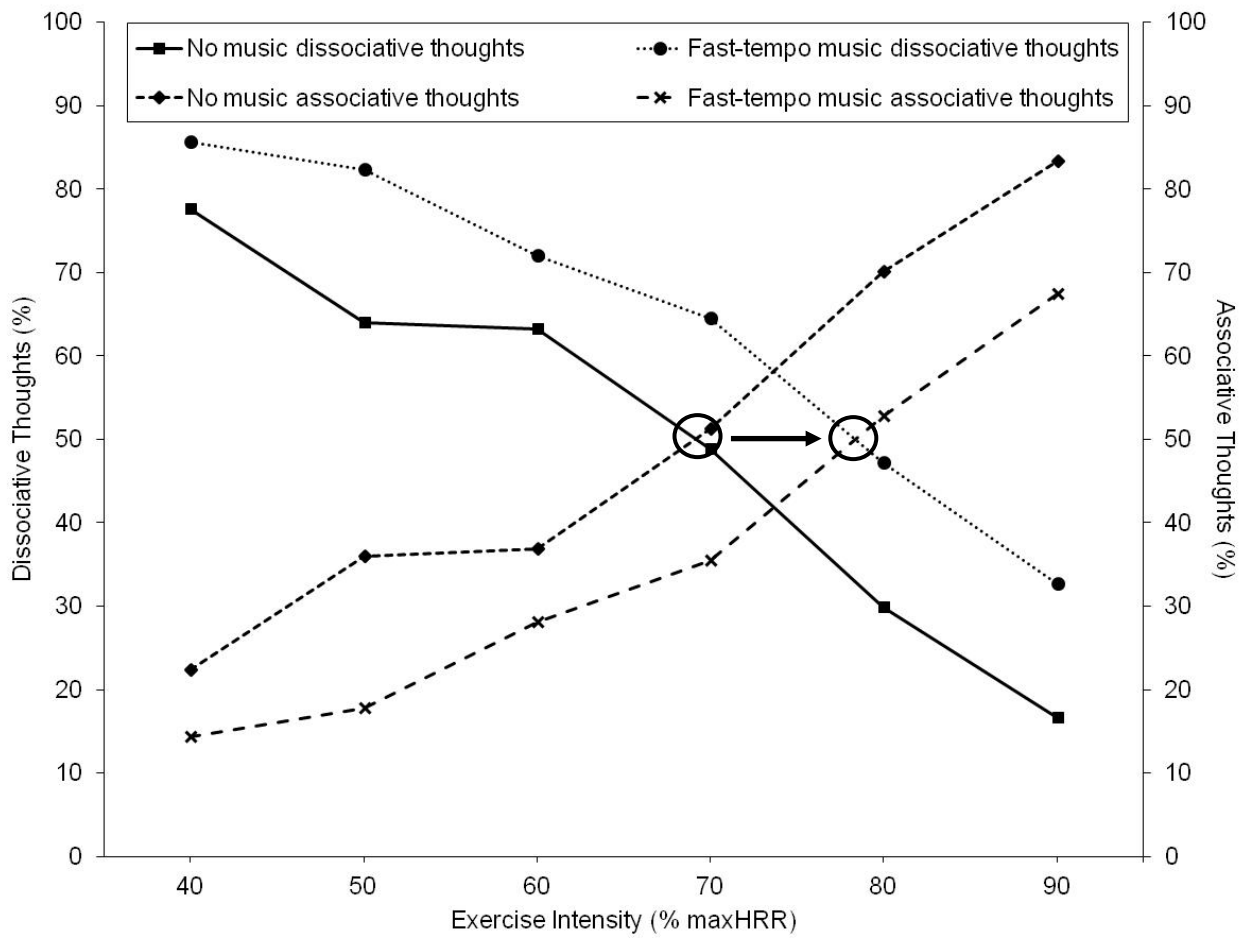


Figure 1. Comparison of state attention scores across all exercise intensities between no-music control and fast-tempo music conditions (from Karageorghis & Jones, 2014).

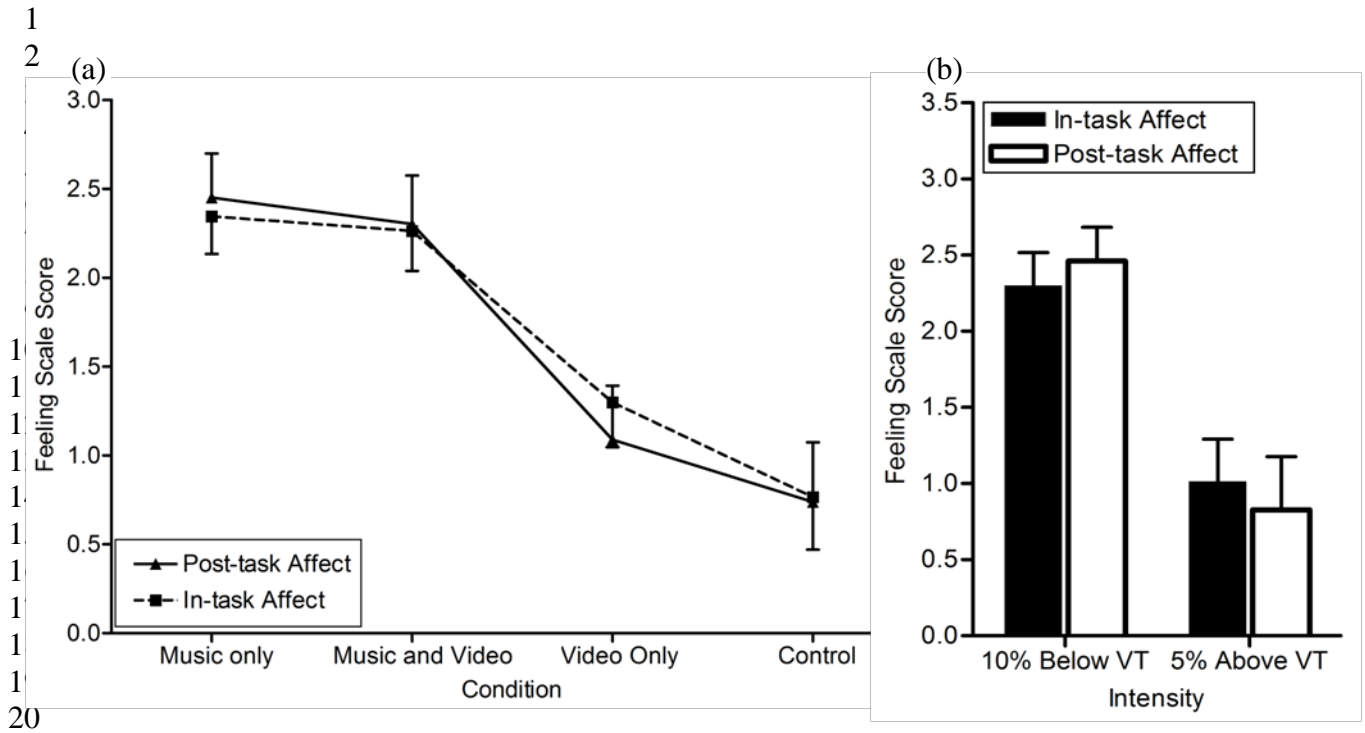


Figure 2. Feeling Scale means and standard errors across conditions (a) and intensities (b). The in-task measures recorded at Minutes 4 and 8 have been averaged and are represented by the “in-task” data points.

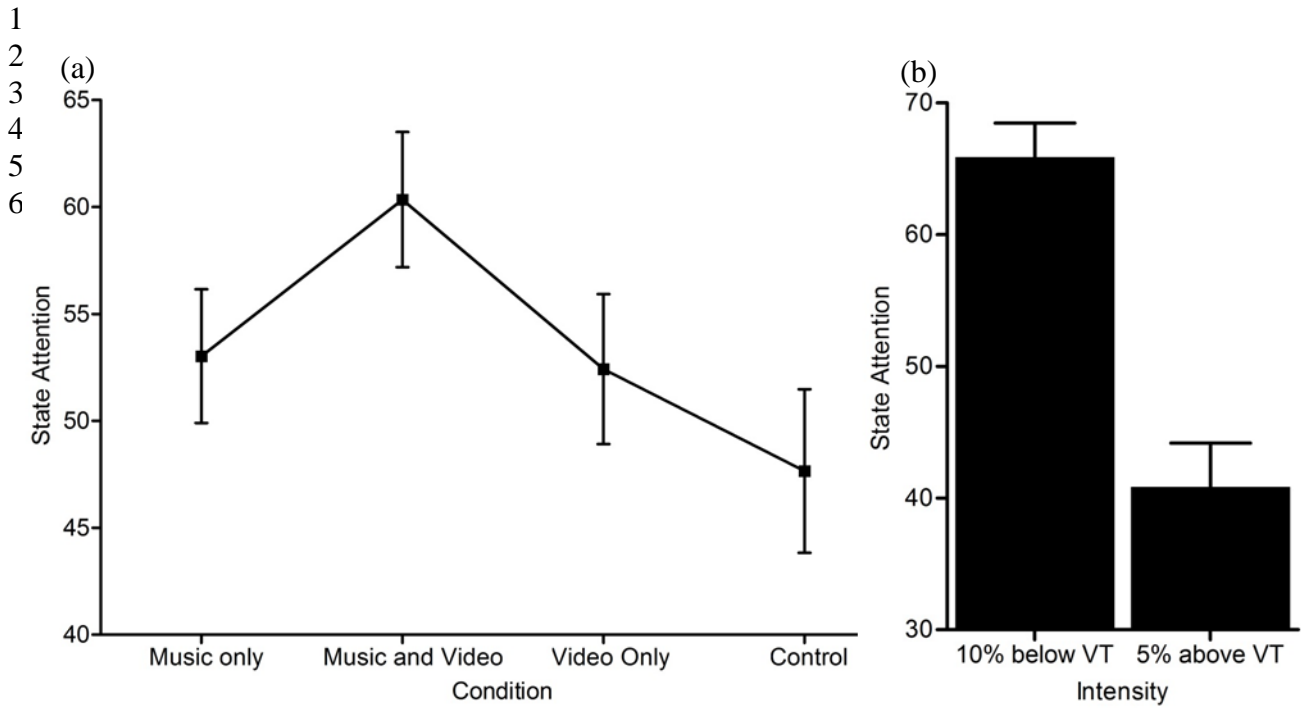


Figure 3. State attention means and standard errors across conditions (a) and intensities (b).