Effects of music and video on perceived exertion during high-intensity exercise

By: Enoch C. Chow and Jennifer L. Etnier

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Abstract:

Background: Dissociative attentional stimuli (e.g., music, video) are effective in decreasing ratings of perceived exertion (RPE) during low-to-moderate intensity exercise, but have inconsistent results during exercise at higher intensity. The purpose of this study was to assess attentional focus and RPE during high-intensity exercise as a function of being exposed to music, video, both (music and video), or a no-treatment control condition.

Methods: During the first session, healthy men ($n = 15$) completed a maximal fitness test to determine the workload necessary for high-intensity exercise (operationalized as 125% ventilatory threshold) to be performed during subsequent sessions. On 4 subsequent days, they completed 20 min of high-intensity exercise in a no-treatment control condition or while listening to music, watching a video, or both. Attentional focus, RPE, heart rate, and distance covered were measured every 4 min during the exercise.

Results: Music and video in combination resulted in significantly lower RPE across time (partial $\eta^2 = 0.36$) and the size of the effect increased over time (partial $\eta^2 = 0.14$). Additionally, music and video in combination resulted in a significantly more dissociative focus than the other conditions (partial $\eta^2 = 0.29$).

Conclusion: Music and video in combination may result in lower perceived exertion during high-intensity exercise when compared to music or video in isolation. Future research will be necessary to test if reductions in perceived exertion in response to dissociative attentional stimuli have implications for exercise adherence.

Keywords: Acute exercise | Attentional focus | Effort | Perceived exertion

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Original article

Effects of music and video on perceived exertion during high-intensity exercise

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1. Introduction

There are many physical and mental health benefits associated with participation in physical activity (PA). However, physical inactivity is widespread and has contributed to the increase in rates of obesity and chronic diseases.[1] Identifying ways to limit sedentary behavior, motivate individuals to become physically active, or encourage exercisers to continue their PA behaviors has developed into a popular area of research. One direction that this research has taken is to test the potential of music and/or video to influence attention in a way that may ultimately result in a change in PA behavior.[2–8]

The term “attention” describes the focus of an individual.[9] The direction of attention or attentional focus during PA has been described as ranging on a continuum from associative to dissociative and as potentially changing throughout the course of the activity.[10] When an individual has an associative focus, he or she concentrates on bodily sensations important for task performance,[11] such as breathing patterns, rhythm in movement, feelings of fatigue in the muscles, and/or heart rate (HR). In contrast, when using a dissociative focus, an individual concentrates on cues that are not relevant for task performance[11] such as auditory/visual stimuli and the environment, and this dissociative focus may provide distraction from his or her internal sensations (fatigue, breathing, and exertion). Based on the parallel-processing model and relevant to PA and exercise, perception is considered an active process that can influence judgments of sensory cues.[12] According to this model, dissociative strategies can reduce ratings of perceived exertion (RPE) during exercise conducted at low-to-moderate intensities. This effect occurs because, while physiological input is important for judgments of exertion, dissociative strategies compete for the

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limited channel capacity necessary to bring perceptions of exertion to awareness. Given this model, identifying ways to increase the extent to which an individual uses a dissociative focus during low-to-moderate intensity exercise may result in a significant reduction in perceived exertion, which may ultimately result in an acute benefit to PA behavior (i.e., greater work output). One way to encourage a dissociative focus is through using music and/or video.[13] Research on music and video shows that each of these stimuli possesses dissociative attentional qualities that may result in an individual perceiving less exertion and increasing performance (work output) during PA.[2–4]

Research conducted on the effect of music during PA suggests that music can be used as an aid to reduce negative bodily sensations and perceived exertion.[14,15] However, consonant with the parallel-processing model, the benefits of music seem to be most consistently evident when an individual participates in low-to-moderate intensity PA.[3,8,14–16] When an individual engages in PA at higher intensity levels, music has been shown to lose its beneficial effect.[16,17] This is in accord with the parallel-processing model because this model suggests that there is a point at which exercise intensity is high enough that a person's focus necessarily becomes more associative and at this intensity, external cues are no longer useful for maintaining a dissociative focus.

A relevant question, of course, is what is meant by "high enough" with regard to the point at which internal bodily sensations dominate attentional capacity despite efforts to adopt a dissociative focus. The dual mode theory suggests that this critical point may be at ventilatory threshold (VT).[18,19] When an individual exercises below his or her VT, cognitive strategies (such as dissociating) are useful to maintain enjoyment of an activity and help an individual perceive that he or she is feeling better. However, when an individual exercises at an intensity level above VT, the dual-mode theory suggests that cognitive processes are more difficult to maintain, the focus shifts to an internal or associative focus due to bodily cues, and pleasure is reduced.

This is further explained by Hutchinson and Tenenbaum[10] who indicate that the relationship between exercise intensity and music's effect on exertion is due to a shift in attentional focus (dissociative to associative) when an individual progresses from low-to-moderate to high-intensity PA. They suggest that at low-to-moderate intensity, individuals can effectively utilize music as a dissociative strategy to distract their focus from their bodily and internal sensations (exertion, fatigue). However, if individuals begin to engage in high-intensity activity, an individual's focus shifts away from the distracter (music) to a more associative strategy (bodily sensations) and the combined effect of the increased physiological effort and the decreased ability to focus externally are reflected in the observed increases in RPE. The result of this increase in perceived exertion is that individuals may perceive PA as too difficult or uncomfortable and the implication is that they may fail to maintain a habit of regular PA. Thus, understanding specifically how music might be used to facilitate the use of a dissociative focus has implications for perceived exertion and performance.

Research examining the effect of video on PA is less prevalent than research on music effects.[6,7,9,13,20] However, from the studies exploring the effects of video in the absence of music, it has also been shown to reduce RPE during exercise.[7,9,20] A limited number of studies[2,5–7] have also compared the combined effects of music and video to the effects of music or video in isolation based on the premise that the 2 in combination may have a stronger effect on attentional focus and RPE.[2]

Barwood et al.[2] examined the effects of no-treatment, a non-motivational video, and a combination of a motivational video and music on performance of a 30 min run consisting of a 15 min warm-up and a 15 min run at maximal effort (average HR = 179.38 bpm) performed in a warm (~26°C) moist (~50% relative humidity) environment. Results showed that participants ran farther in the music and video condition than in either other condition despite reporting similar levels of RPE. Based on participants running farther without experiencing an increase in RPE, Barwood et al.[2] concluded that combined music and video did have a beneficial effect on perceived exertion during maximal exertion exercise, apparently countering findings of previous literature. However, even if one accepts Barwood et al.'s interpretation of their findings, their study design negates the ability to attribute their findings to the unique effects of music and video in combination. In particular, their independent variable was actually motivational quality (absent, non-motivational, and motivational) rather than comparing combined music and video effects to effects of either in isolation.

In another study designed to explore the combined effects of music and video, Lin and Lu[7] asked participants to exercise "as hard as possible" on a stationary bicycle for 12 min while in no-treatment, music, video, and combined music and video conditions. Results indicated that HR was equivalent across the 4 conditions (range of means = 174–178 bpm). However, RPE were significantly less in all treatment conditions as compared to the control condition, and the amount of work completed was significantly greater in the combined condition than in the control condition. Importantly, this is the first study to demonstrate that the effects of combined music and video differ from those of music or video in isolation when participants exercise at a high-intensity level (average HR = 88% age-predicted maximum HR, JH Lin, personal communication, February 27, 2015). However, there are 2 limitations of this study. First, the researchers did not assess the effects on attentional focus, hence limiting our ability to identify the role of attentional focus in this relationship. Second, because participants were asked to exercise at a particular level of perceived exertion (i.e., "as hard as possible"), the influence of the combined intervention on perceived exertion actually had the potential to influence the exercise intensity itself and this is clearly a threat to the internal validity of the study.

Two studies have tested the effects of music and video in combination on attentional focus and/or RPE at objectively-determined high intensity levels. Jones et al.[6] asked participants to exercise for 10 min at +10%VT (average HR = 150.44 bpm) and −5%VT (average HR = 131.87 bpm) under conditions where they listened to music, watched video, had the combination of music and video, or were in a control condition. Results indicated that attention was most dissociative in the combined condition as compared to the other 3 conditions and this effect was evident regardless of exercise intensity. However, one limitation of this study is that they did not include measures of RPE so it is not clear if this dissociative focus was reflected in a decreased perception of exertion.

Hutchinson et al.[5] used a within-subjects design to compare the effects of music, music and video, and no-treatment on exercise performance at −10VT (target HR = 148.4 bpm) and at +10VT (target HR = 181.5 bpm). Their results showed that regardless of exercise intensity, the music and video condition resulted in significantly lower RPE as compared to the no-treatment condition. Additionally, irrespective of exercise intensity, the extent to which the participants were able to dissociate was significantly greater for music and video as compared to music only which was also significantly greater than the no-treatment condition. The limitation of this study is that the researchers did not include a video only condition, so their results do not allow for conclusions as to whether or not music and video is better than video alone in terms of its impact on attentional focus and RPE.

Given the limitations of the extant literature exploring the possibility that music and video in combination can benefit exercise performance and perceived exertion during exercise above VT, the purpose of this study was to use a complete design to compare the effects of music, video, and the combination of music and video on attentional focus and RPE during high-intensity exercise. This study was designed to address the limitations of the past research in 3 ways: (1) by measuring attentional focus and RPE, (2) by including all 4 possible combinations of music (present/absent) and video (present/absent), and (3) by using an objective and self-referenced exercise intensity to ensure that participants were exercising at a high-intensity (operationalized as +25%VT). It was hypothesized that participants in the combined music and video treatment group would report a more dissociative focus and lower RPE when compared to the music only, video only, or control conditions. Based on past research and the parallel processing model, it was further hypothesized that at this high-intensity of exercise, music alone and video alone would have a negligible impact on attentional focus and RPE as compared to the control condition.

2. Methods

2.1. *Participants*

Healthy male participants ($n = 15$; age: 21.87 ± 1.41 years, mean ± SD) were recruited from a large university in the southeastern United States for participation. We limited the sample to men because we were concerned that even regularly active female participants might not be able to complete the exercise protocol on the stationary cycle at +25%VT because of their lesser muscle mass in the legs. All participants signed a consent form (approved by the institutional review board) and confirmed that they were healthy enough to participate in PA using the American College of Sports Medicine's (ACSM's) Preparticipation Questionnaire (2006). Our inclusion criteria required that if a participant had a prior history of health problems (heart disease, pulmonary disease, and stroke), was physically unable to perform the cycling task, was taking medication (e.g., for asthma) that could influence exertion or coordination during PA, or had a condition that limited maximal output during PA, he would not be permitted to participate without consent from a medical doctor. However, all of our participants were healthy enough to participate without a physician's consent. All participants had to be regularly active (30 min/week at least 3 time/week) for 6 months prior to beginning the study. This was assessed using the Godin Leisure Time Exercise Questionnaire.[21] This requirement was necessary to ensure that participants would be able to complete the high-intensity exercise sessions.

2.2. *Materials and measures*

2.2.1. *RPE*

During all sessions, a participant's RPE was measured using the Borg RPE scale[22] as a measure of perceived exercise intensity. This scale ranges from 6 (*very, very light*) to 20 (*very, very hard*). Scherr et al.[23] reported strong correlations between RPE and HR ($r = 0.74$) and between RPE and blood lactate ($r = 0.83$) during incremental exercise and concluded that RPE could be used as an accurate tool to monitor an individual's exercise intensity.

2.2.2. *Attention*

Attentional focus was measured using a visual analog scale ranging from "0" indicating pure dissociation to "10" indicating pure association.[3,24] Attention was measured in millimeters (mm); thus, a 100 mm vertical line separated the numeric anchors. Participants were asked to draw a line perpendicular to the line reflecting their attentional focus. The location of this perpendicular line was measured starting from the 0 mm mark. Fifty millimeters was considered a neutral focus where a participant was equally dissociating and associating while cycling. Any measurement less than 50 mm was considered a dissociative focus, while a measurement more than 50 mm was considered an associative focus.

2.2.3. *HR*

Participants were fitted with a Polar HR monitor (Model F6; Polar Electro, Lake Success, NY, USA) prior to beginning the exercise. Participants were asked to wear the HR monitor and sit quietly for 5 min. Upon completion of the sitting period, baseline HR was assessed. HR was then assessed after the 5 min warm-up (0 min) and every 4 min during the 20 min exercise bout.

2.2.4. *Distance*

The distance covered (in kilometers) during the exercise session was recorded after the 5 min warm-up (0 min) and every 4 min during the 20 min exercise bout. Distance covered by the participant was displayed on a digital screen located on the bicycle such that only the researcher could view the screen.

2.2.5. *Exercise intensity*

Exercise intensity was determined relative to VT calculated following a maximal exercise test. This was done because VT is thought to be critical in determining the extent to which central physiological cues dominate over external psychological factors.[16,18] Participants were fitted with a facemask that covered their nose and mouth and that allowed for the capture of exhaled air by the Viasys Vmax Encore 29c metabolic cart (SensorMedics, Yorba Linda, CA, USA). Participants performed a ramped exercise protocol in which they started exercising at 100 W for 3 min and resistance was increased by 25 W every 3 min until volitional exhaustion. VT was calculated by the Vmax Series Software V20-1a (Viasys Health Care, Yorba Linda, CA, USA) from data collected by the metabolic cart during the graded exercise test. This software system uses dual criteria of the ratio of pulmonary ventilation to oxygen consumption (Ve/VO_2) and the ratio of pulmonary ventilation to carbon dioxide production (Ve/VCO_2) to identify VT. The VT identified by the software was confirmed for the first 5 participants using the modified V-slope method which requires visual inspection of the test data plotted with VO_2 on the x-axis and Ve on the y-axis to identify the point at which the slope of the relationship changes from linear to exponential. After a participant's VO_{2max} and VT were calculated, the participant's workload (resistance on the ergometer in Watts) that corresponded to high intensity (125%VT) was identified. In the rare instances ($n = 2$) when the participant's 125%VT fell in between 2 workloads, the researcher identified the workload which corresponded to 70%VO_{2max} (another measure of high intensity) and this was used as the workload for the subsequent exercise sessions. The ACSM guidelines[25] classify 125%VT and/or 70%VO_{2max} as high-intensity exercise. The maximal exercise test and all exercise sessions were performed on a Corival Lode recumbent bicycle ergometer (Lode, Groningen, the Netherlands).

2.2.6. *Treatment conditions*

In all treatment conditions, the final 20 min (before credits containing songs "Urban" and "Jardin Chinois") of Cirque du Soleil: *La Nouba* was selected and presented to the participants. This particular choice for the treatments was selected because the music and video had audio or visual consistency when presented in isolation, and when combined the stimulus was still harmonious and did not give the perception of being disjointed. The entertainment selection also did not have any vocals and the music was an acoustic-based instrumental. All participants selected a comfortable volume level for the headphones (QuietComfort® noise-canceling headphones; BOSE GmbH, Friedrichsdorf, Germany) during their first session and then in future exercise sessions, this same volume was used.

In the music condition, participants listened to music through noise-canceling headphones. Participants only heard the music and were not able to view the video. In the video condition, participants watched the segment of video on a computer monitor (Apple MacBook 13″ × 8.5″ display; Apple Inc., Cupertino, CA, USA). While viewing the video segment, participants wore noise-canceling headphones but no music or noise was projected through them. In the music and video combined condition, participants listened to the music through noise-canceling headphones and viewed the video segment simultaneously. In the control condition, participants were fitted with noise-canceling headphones but no sound was projected through them and the television remained turned off.

2.3. *Procedures*

The study consisted of 5 sessions for each participant. Every session was separated by at least 48 h and occurred during the same hour of the day. Participants were asked not to engage in any PA 2 h prior to testing, not to engage in high-intensity PA at all on the day of the test, and not to eat or consume caffeine 3 h before the test.

On the first day of the study, participants signed the consent and completed questionnaires. Participants were then equipped with an HR monitor and their baseline HR was measured. After this measure was taken, they began the ramped exercise test. Participants were asked to cycle on a stationary bicycle at 80–95 rpm, and the workload on the bicycle was set at 100 W for all participants. Every 3 min the workload was increased by 25 W until the participant reached his volitional exhaustion. During the last minute of every 3 min interval, RPE, attentional focus, HR, and distance were measured. The graded exercise test concluded when the participant could no longer tolerate an increase in workload or maintain the minimum cycling cadence of 70 rpm and volitionally terminated the test. Participants were deemed to have reached a "true" VO_{2max} if they met at least 2 of 3 criteria for the maximal test (RPE over 17, HR over 170 which equates to approximately 85% age-predicted max for this sample, respiratory quotient over 1.10). All participants met this requirement. Upon completion of the VO_{2max} test, participants were randomly assigned to one of 4 possible orders of presentation of the 4 treatment conditions.

During the 4 experimental sessions, all participants performed the same cycling task; only the treatment differed. All participants were given an HR monitor and proceeded to the stationary bicycle. The cart holding the video projector and the stationary bicycle were positioned in the exact same location for every session regardless if a participant was exposed to a treatment. The video projector was a 13-inch flat screen computer monitor positioned on a cart approximately 3.5 feet from the seat of the bicycle and at eye level of a seated participant. The monitor was slightly offset to the right by 2 inches so that the bicycle pedals would not strike the cart and so that the monitor was in the direct eye line of the participant. Participants were free to adjust the seat before an exercise bout to compensate for their height. During the 5 min warm-up, exercise intensity was gradually raised to the calculated workload reflecting 125%VT and this time-point was recorded as the 0 min measurement. All participants maintained cycling at this workload and pedaled at a speed of between 80 and 95 rpm for additional 20 min. RPE, HR, attentional focus, and distance were recorded during the last 40 s of every 4 min segment until conclusion of the 20 min. If a participant was not maintaining his work rate at 80–95 rpm, he was encouraged to increase or decrease his cycling speed in order to return to the desired rpm range. In all cases, workload was reduced by 10 W if the participant could not maintain the rpm requirement so that participants could complete 20 min of activity. This occurred for 2 participants on 2 occasions.

Verbal cues were not otherwise given to a participant during a session. When participants completed all experimental conditions, they were debriefed and compensated USD50 for completing the study.

2.4. *Statistical analysis*

The study used a randomized-conditions within-subjects experimental design. Given the design of the study, a power analysis conducted using G*Power 3.0.10[26] indicated that with $n = 16$, there would be sufficient statistical power ($\beta = 0.80$) to observe a statistically significant effect ($\alpha < 0.05$) with an observed medium-to-large effect ($f = 0.30$). Data for distance and HR were evaluated using two-way repeated measures analyses of variance (RMANOVAs) to test the effects of treatment (control, music, video, and combined) and time (0 min, 4 min, 8 min, 12 min, 16 min, 20 min). Data for RPE and attentional focus were evaluated using two-way RMANOVAs to test the effects of treatment (control, music, video, and combined) and time (4 min, 8 min, 12 min, 16 min, and 20 min). Mauchly's test of sphericity was examined for all effects and when necessary a Huynh–Feldt adjustment was made. *Post hoc* analyses were conducted for significant main effects and simple effects were compared for significant interactions. Analyses were conducted using IBM SPSS Statistics Version 21.0 (IBM Corp., Armonk, NY, USA).

3. Results

Descriptive data for HR, RPE, attentional focus, and work completed for each condition and at each measurement point are presented in Table 1.

3.1. *Distance*

Distance was not normally distributed for any combination of Treatment × Time. Hence, the necessary assumptions for repeated measures ANOVA were not satisfied. For this reason, we only present descriptive data in Table 1 to illustrate that the distance covered increased as time increased on the cycling task from the end of the 5 min warm-up (0 min: 1.93 ± 0.07 kg, mean ± SE) through the 20 min of exercise (4 min: 3.85 ± 0.12 kg; 8 min: 5.98 ± 0.16 kg; 12 min: 8.23 ± 0.26 kg; 16 min: 10.52 ± 0.29 kg; 20 min: 12.53 ± 0.35 kg) with the increase over time remaining steady across the various time periods.

3.2. *HR*

There were no significant differences in HR as a function of the interaction of Treatment × Time ($F(8.87,\ 124.22) = 1.18$, $p > 0.32$, partial $\eta^2 = 0.08$.) As expected, there was a significant difference in HR as a function of time ($F(1.29, 18.01) = 442.73$, $p < 0.001$, partial $\eta^2 = 0.97$), but there was no significant difference in HR as a function of treatment ($F(3, 42) = 0.38$, $p > 0.77$, partial $\eta^2 = 0.03$). The main effect for time indicated that HR increased significantly from baseline (73.47 ± 1.79 bpm) to the first 4 min of exercise (144.30 ± 3.31 bpm) and then continued to increase significantly as time engaged on the cycling task increased (8 min: 151.03 ± 3.72 bpm; 12 min: 154.30 ± 3.89 bpm; 16 min: 157.22 ± 3.92 bpm; 20 min: 160.23 ± 3.93 bpm).

3.3. *RPE*

There was a significant interaction between treatment and time ($F(7.67,\ 107.42) = 2.34$, $p = 0.03$, partial $\eta^2 = 0.14$). In particular, from 8 min to 12 min and from 16 min to 20 min, RPE increased less during the combined condition (8 min–12 min: $M_{change} = 0.67$; 16 min–20 min: $M_{change} = 0.00$) than it did for the other 3 treatment conditions (8 min–12 min: $M_{change} = 1.22$; 16 min–20 min: $M_{change} = 0.62$) (Fig. 1A).

Table 1
Descriptive statistics by measurement time and condition (mean ± SD).

	4 min	8 min	12 min	16 min	20 min
Control					
HR (bpm)	143.80 ± 14.61	151.67 ± 15.84	154.80 ± 15.89	156.67 ± 16.02	159.13 ± 15.72
Distance (km)	3.87 ± 0.64	6.07 ± 0.70	8.13 ± 1.06	10.53 ± 1.13	12.47 ± 1.36
RPE	12.33 ± 2.13	13.13 ± 2.30	14.60 ± 1.81	15.27 ± 2.02	16.20 ± 2.15
Attentional focus	39.93 ± 26.93	56.13 ± 22.42	69.27 ± 20.03	75.87 ± 22.11	79.93 ± 19.58
Music only					
HR (bpm)	145.13 ± 14.77	151.87 ± 16.13	154.33 ± 16.47	158.33 ± 16.67	162.20 ± 17.37
Distance (km)	3.73 ± 0.70	6.00 ± 0.66	8.20 ± 1.01	10.53 ± 1.13	12.60 ± 1.24
RPE	11.80 ± 1.74	13.33 ± 1.54	14.33 ± 1.80	15.07 ± 1.91	15.47 ± 2.17
Attentional focus	33.07 ± 20.91	49.13 ± 21.45	60.40 ± 21.59	69.13 ± 20.73	77.40 ± 16.23
Video only					
HR (bpm)	144.67 ± 13.79	151.60 ± 15.95	154.40 ± 16.79	158.07 ± 16.46	160.40 ± 16.94
Distance (km)	3.93 ± 0.26	5.93 ± 0.59	8.33 ± 1.11	10.53 ± 1.13	12.53 ± 1.46
RPE	11.60 ± 1.72	13.07 ± 1.49	14.27 ± 1.71	14.73 ± 1.71	15.27 ± 2.09
Attentional focus	28.27 ± 19.60	42.73 ± 22.58	59.20 ± 18.58	68.47 ± 19.43	72.13 ± 20.18
Music and video					
HR (bpm)	143.60 ± 13.13	149.00 ± 13.91	153.67 ± 14.53	155.80 ± 14.81	159.20 ± 13.83
Distance (km)	3.87 ± 0.52	5.93 ± 0.59	8.27 ± 1.10	10.47 ± 1.13	12.53 ± 1.46
RPE	10.53 ± 1.06	12.13 ± 0.83	12.80 ± 1.08	13.47 ± 0.99	13.47 ± 1.13
Attentional focus	22.87 ± 14.77	33.20 ± 17.07	43.53 ± 18.97	53.20 ± 18.73	56.80 ± 22.45

Abbreviations: bpm = beats per minute; HR = heart rate; RPE = ratings of perceived exertion.

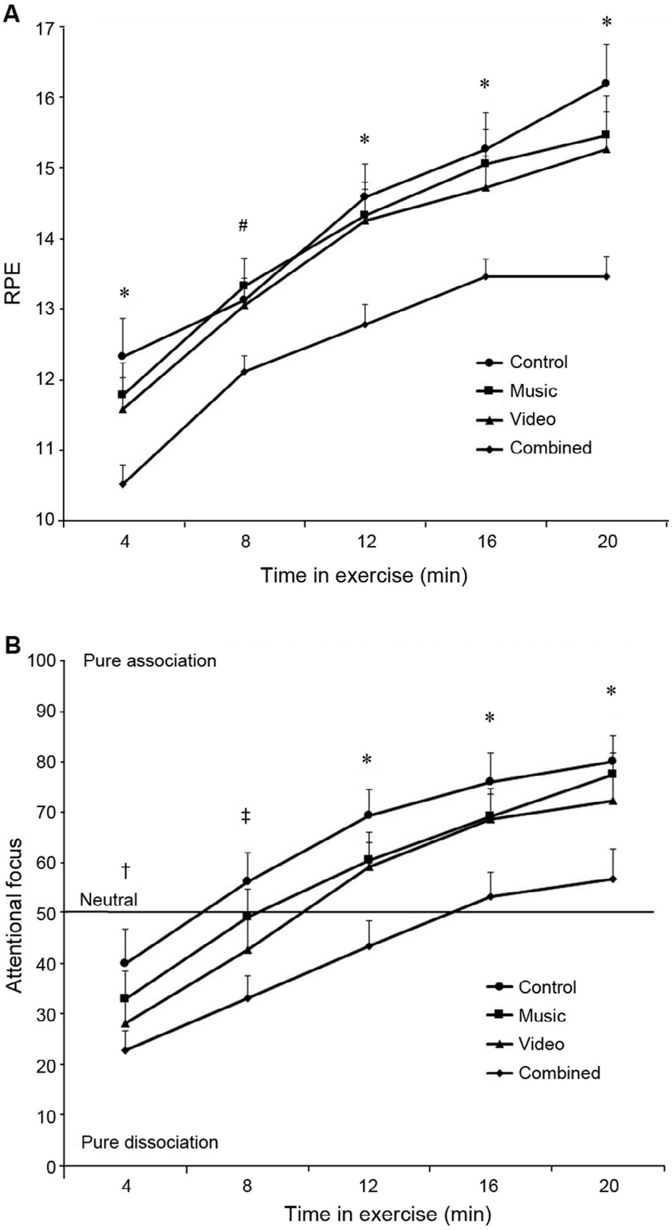

Fig. 1. Means ± SE values for (A) ratings of perceived exertion (RPE) and (B) attentional focus as a function of the significant interaction of time by treatment. Anchors for the attentional focus scale are included on the *y*-axis. *Combined group is significantly different from all 3 other groups; #Combined group is significantly different from the music only and video only groups; †Combined group is significantly different from control group; ‡Combined group is significantly different from the control group and the music only group.

3.4. *Attentional focus*

There was no significant interaction between treatment and time ($F(12, 168) = 1.25, p = 0.26$, partial $\eta^2 = 0.08$). There were significant main effects for treatment ($F(3, 42) = 5.68$, $p = 0.002$, partial $\eta^2 = 0.29$) and time ($F(1.38, 19.30) = 81.08$, $p < 0.001$, partial $\eta^2 = 0.85$). Attentional focus was significantly ($p < 0.05$) more dissociative in the combined condition (41.92 ± 4.21) when compared to the music only (57.83 ± 4.66), video only (54.16 ± 4.68), and control (64.23 ± 5.34) conditions. There was no significant difference in attentional focus between the music only, video only, and control conditions ($p > 0.05$). The main effect for time showed that an individual's attentional focus shifted significantly toward a more associative focus as time engaged in the cycling task increased (4 min: 31.03 ± 3.78; 8 min: 45.30 ± 3.50; 12 min: 58.10 ± 3.67; 16 min: 66.67 ± 3.87; 20 min: 71.57 ± 3.53) (Fig. 1B).

4. Discussion

The parallel-processing model predicts that dissociative strategies that focus attention away from task-relevant bodily cues will compete with physiological input for access to limited attentional challenges and will result in the perception of less exertion during low-to-moderate intensity exercise. However, at higher intensities of exercise, physiological cues are expected to dominate attention to the extent that dissociative strategies lose their effectiveness.[12] It has been suggested that by combining music and video, perceived exertion may be lowered even at higher intensities of exercise.[2] However, research examining the potential benefits of presenting music and video in combination is very limited,[2,5–7] and there is no past research in which definitive statements could be drawn regarding the potential additive effects of music and video in combination on attentional focus and RPE during high-intensity exercise. Hence, the purpose of this study was to examine if the presentation of combined music and video while cycling would influence an individual's perceived exertion during high-intensity exercise.

Results of this study support previous research[2,16,17] in that during high-intensity exercise, music or video in isolation is not effective at influencing attentional focus or RPE in comparison to a control condition. As previous researchers have noted[10] and concordant with the parallel-processing model,[12] it is likely that at this higher intensity of exercise, an associative focus begins to dominate as the physiological demands of the exercise become increasingly attention-demanding. However, the findings also indicated that when participants were presented with music and video simultaneously, they reported a significantly lower RPE when compared to the other treatment conditions (music only, video only, and control), despite exercising at the same workload, having the same HR response, and covering the same virtual distance. Importantly, this effect tended to increase with time so that as the duration of higher intensity exercise increased, the benefits of the combined music and video actually became more pronounced. This finding supports our hypothesis that participants would report a lower RPE when presented with music and video simultaneously compared to the other conditions. We also hypothesized that participants would report a more dissociative focus throughout the cycling task in the combined condition than when given music only, video only, or the control condition. The results also supported this hypothesis as participants rated their attentional focus as significantly more dissociative in the combined condition than when compared to the other conditions. This provides an important extension to the literature because the findings demonstrate that music and video in combination do provide greater benefits to exercisers than either provided in isolation even when performing high-intensity exercise.

The results of this study demonstrate that participants cycling for 20 min at an intensity level above VT were unable to maintain a dissociative attention style when presented with music only, video only, or control conditions. This was determined through the participants' rating of attentional focus at each 4 min time point. In all conditions, the main effect for time indicated that attentional focus became increasingly less dissociative over the course of the 20 min exercise session (Fig. 1B). However, when in the combined condition, participants started out with a focus that was much more dissociative than when in the other conditions, and hence they were able to maintain a dissociative or neutral focus through 12 min and their focus only became slightly associative by 16 min. In contrast, when in the other 3 conditions, participants switched from a dissociative to an associative focus by the 12 min point. Thus, it appears that the combined music and video provided an attentional distraction that kept participants' focus more dissociative and this occurred in conjunction with the reporting of a lower RPE. Future research will be necessary to determine if the change in attentional focus over time due to external distracters mediates the delayed onset of perceived exertion over time.

Before discussing the conclusions of this study, it is important to consider the limitations. The first limitation is that the sample was a relatively homogeneous group consisting of young, regularly active men. Hence, the results may not generalize to other samples, and future research is necessary to determine if these effects are possible in other populations. Second, the specific type of music/video that was selected was purposefully selected to ensure that treatment conditions only differed in the intended fashion (i.e., due to the level of the independent variable). Future research will be necessary to see if other music/video combinations that differ in terms of potentially relevant variables (e.g., beat, motivational quality, preference, and synchronicity) produce similar effects as were found with this particular selection. Third, although we chose an intensity of exercise that is considered to be hard (high-intensity) according to ACSM guidelines,[25] obviously there are higher intensities of exercise at which we might not see the same beneficial effects of music and video in combination. Relatedly, because this level of exercise intensity is not one that would likely be chosen by a recreational exerciser, the implications relative to enhancing exercise adherence through music and video remain to be explored. Lastly, although it has been suggested that the effects of music/video on RPE are mediated by attentional focus, the within-subjects design of this study limited our ability to statistically test for mediation. Future study using a between-subjects design and appropriate meditational techniques will be necessary to assess the extent to which differences in attentional focus actually explain differences in RPE.

5. Conclusion

Based on the findings of this research, it is concluded that young, regularly active men engaging in a 20 min bout of high-intensity exercise are able to use music and video in combination as a method to maintain a dissociative focus and perceive significantly lower exertion during their exercise bout. This finding is important because it suggests that by combining video and music, benefits can be obtained at a higher intensity of exercise than previously observed. If these effects are replicated and found to extend to other populations, the implication is that combined video and music may serve to lessen the perceived exertion required for a high-intensity exercise bout and that a mediator of this effect is attentional focus. One logical follow-up to this research would be to explore whether or not this effect on perceived exertion has implications for exercise adherence. If an exerciser perceives that he is working less hard, it is possible that he will exercise for longer or that he will return to exercise again. Furthermore, given that the current guidelines for PA[25] include vigorous intensity exercise as one option for meeting recommendations, understanding ways to reduce perceptions of exertion during high-intensity exercise may have important public health implications. Although future study in this area is necessary and encouraged, the findings of this study make an important extension to the literature by demonstrating that music and video can be used in combination to reduce RPE even when exercising at a high intensity.

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Authors' contributions

ECC conceived of the study, collected and analyzed the data, and drafted the manuscript; JLE provided input into the design of the study, assisted with data analysis and interpretation, and provided input and editorial feedback throughout the writing and revising of the manuscript. Both authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

Neither of the authors declare competing financial interests.

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Erratum

Erratum to "Effects of music and video on perceived exertion during high-intensity exercise" [J Sport Health Sci 6 (2017) 81–88]

This is an erratum to our published paper entitled "Effects of music and video on perceived exertion during high-intensity exercise".[1]

In the paper mentioned above, there are some errors that we want to clear in this erratum.

On page 83, "%" was missed in 2 places in the penultimate paragraph of the Introduction. The details are as follows:

> Hutchinson et al. used a within-subjects design to compare the effects of music, music and video, and no-treatment on exercise performance at −10VT (target HR = 148.4 bpm) and at +10VT (target HR = 181.5 bpm).

should be corrected as

> Hutchinson et al. used a within-subjects design to compare the effects of music, music and video, and no-treatment on exercise performance at −10%VT (target HR = 148.4 bpm) and at +10%VT (target HR = 181.5 bpm).

The editorial office would like to apologize for any inconvenience caused.

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