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Affective responses to high-intensity interval training with continuous and respite music

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Abstract

Music has been shown to enhance affective responses to continuous exercise, but the most effective application of music during interval exercise is poorly understood. This study examined two contrasting applications of music designed to assuage the decline in pleasure often experienced during high-intensity interval training (HIIT). In a repeated measures crossover design, 18 recreationally active participants (10 men and 8 women; M_{age} = 25.1±5.1years; M_{BMI} = 23.08±2.01kg/m 2 ; *M* VO_{2max} = 38.82±10.73ml/kg/min) completed three HIIT sessions (10 x 60s efforts at 100% Wmax, separated by 75s recovery) on a cycle ergometer. Participants completed two experimental conditions: respite music (applied only during the recovery periods), continuous music (applied throughout the entire HIIT session); and a no-music control condition. Results indicated that music did not influence affective valence during the work bouts or recovery periods of the HIIT sessions (*p*s > .05), but that listening to music continuously elicited greater post-task enjoyment (p = .032, d = 0.66) and remembered pleasure (p = .044, d = 0.5). This study is the first to investigate the application of music during a practical HIIT protocol and to compare the effects of respite versus continuous music during interval exercise.

Keywords: Cycling, Enjoyment, HIIT, Pleasure

Researchers and practitioners are seeking innovative ways to help the general population engage in sufficient physical activity in order to garner health benefits. Interval exercise has been proposed as a viable means to accrue health benefits and is a shorter duration alternative to continuous exercise. Interval exercise is a variable form of exercise that generally includes intermittent bouts of high-intensity exercise separated by periods of recovery (Gibala et al., 2014). Specifically, high-intensity interval training (HIIT) typically includes intense but submaximal efforts that elicit ≥80% of maximal heart rate (HRmax), and sprint interval training (SIT) involves workloads associated with ≥100% maximal oxygen uptake (VO_2max; Weston et al., 2014). While the physiological benefits associated with interval exercise have been established (Batacan et al., 2017; Gibala et al., 2014; Weston et al., 2014), concerns have been raised about the suitability of such protocols for the general population (Hardcastle et al., 2014). One of these concerns focuses on the affective responses to interval exercise and the detrimental effect these might have on future exercise behaviour.

Several HIIT studies have found pleasure to decline *during* the exercise sessions (e.g., Decker & Ekkekakis, 2017; Jung et al., 2014; Oliveira et al., 2013). Jung et al., (2014) demonstrated that individuals of normal bodyweight experienced a drop from feeling '*Good*' (3.02±0.24 on the Feeling Scale [FS]; Hardy & Rejeski, 1989) immediately prior to a HIIT session to feeling '*neutral-fairly bad*' (-.40±0.45) toward the end of session. This contrasted with a smaller decline in pleasure during the continuous moderate-intensity condition from 3.15±0.21 ('*Good*') to 2.10±.29. Similarly, Stork et al., (2018) reported declines in core affect into the negative valence (displeasure) during HIIT and SIT protocols (in-task reductions of 3.80±2.91 and 2.73± 2.52 on the FS, respectively), whereas core affect remained positively valenced (pleasure) during a moderate-intensity continuous protocol. Importantly, in-task affect has been shown to predict future exercise behaviour (e.g. Rhodes & Kates, 2015; Williams et al., 2012). However, while this affect-behaviour relationship has been demonstrated with continuous exercise, the evidence for this relationship with respect to interval exercise is understudied (Stork et al., 2018). Nonetheless, strategies that seek to eliminate or minimise the decline in pleasure often experienced during interval exercise sessions are warranted (Stork et al., 2017).

Music as a Pleasure Enhancing Strategy

Music is commonly implemented to increase the pleasure and enjoyment associated with an exercise session. The application of music before, during, and after exercise has been the subject of an extensive body of work (see Karageorghis, 2017) and its capacity to positively influence affective responses during continuous exercise is well documented (e.g., Jones et al., 2014; Terry et al., 2012). Similarly, the capacity of music to positively influence postexercise enjoyment has been documented (e.g., Jones et al., 2014; Stork, Kwan, Gibala, & Martin Ginis, 2015).

It has been proposed that music promotes greater pleasure during exercise owing to its capacity to capture the attention of the listener (Karageorghis & Priest, 2012a). However, extant theory postulates (Rejeski, 1985) and research evidence indicates (Karageorghis & Jones, 2014) that the effects of external stimuli (e.g., music) are reduced at high-intensity workloads owing to limited attentional capacity available to process such stimuli. Further, Ekkekakis (2003), based on work by Joseph LeDoux, describes that interoceptive (e.g., respiratory, muscular) cues bypass the somatosensory and prefrontal cortex and take a *low road* directly to the amygdala during high-intensity exercise. Therefore, external stimuli might have less influence on affective responses during high-intensity exercise because the interoceptive signals are not cognitively processed and received prior to external stimuli. However, the recovery periods of HIIT sessions offer respite from the high workloads and might afford greater opportunity to process external stimuli.

Initial studies on the effects of music during interval exercise have demonstrated that music can mitigate the decline in pleasure typically experienced during interval exercise and increase enjoyment reported postexercise. Stork, Karageorghis, and Martin Ginis (2019) applied researcher-selected music throughout a SIT session consisting of 3 x 20-s “all-out” sprints among insufficiently active adults. They found that post-SIT enjoyment was greater in the music condition compared to the podcast and no-audio control conditions, and pleasure over the course of the SIT trial was more positive in the music condition compared to the no-audio control when examined across all work bouts and recovery periods. Similarly, Stork et al., (2015) applied self-selected music continuously throughout a 4 x 30-s “all-out” SIT session among recreationally active adults and found that post-SIT enjoyment was significantly higher in the music condition compared to a no-music control condition. However, although pleasure was consistently more positive during SIT in the music than control condition, these differences were not statistically significant.

In an alternative application of music during interval exercise, Jones et al., (2017) played music only during the 3-min rest periods of a HIIT session consisting of 5 x 5-min bouts at 20% of the difference between GET (gas exchange threshold) and VO2max. Jones et al., (2017) coined the term *respite music* which was operationalised to describe the application of music only during periods of recovery within an exercise session. Fast-tempo (125-135 bpm) respite music elicited a significant positive effect on pleasure during the 3-min recovery periods of the interval session when compared to a no-music control condition. Hutchinson & O’Neil, (2019) applied respite music during a 10-min recovery period between two 30-s sprints in order to examine if respite music could enhance repeated sprint performance. Notably, these two studies implemented exercise protocols that were purposely designed to have long rest periods (i.e., 3-10mins) for the application of respite music. Thus, the effects of respite music during a more practical HIIT protocol (i.e., with shorter recovery periods) are currently unknown and it is unclear if the previously reported effects on in-task pleasure (e.g., Jones et al., 2017) will re-emerge.

While the initial evidence of the efficacy of respite music has been promising, the unorthodox application of respite music raises questions regarding its practicality and whether this different application of music confers additional benefits over more typical applications of music. Respite music more readily affords the opportunity to incorporate emotionally salient and/or motivational aspects of a track during recovery periods between bouts when an exerciser has greater attentional capacity to process information. Respite music can be applied to ensure that an exerciser benefits from the most motivational segments of a track, while such control is more difficult with the application of continuous music. Given these potential benefits of respite over continuous music, further investigation appears to be warranted.

While initial evidence for the benefits of music during HIIT (Jones et al., 2017) and SIT (Stork et al., 2015; Stork & Martin Ginis, 2016) holds promise, those studies administered particularly intense HIIT and SIT protocols that might be less applicable to the general population. Researchers have shifted toward studying less intense and more practical forms of HIIT and SIT that may be more appropriate for the general population (e.g., Stork et al., 2018; Vollaard & Metcalfe, 2017). Therefore, there appears to be merit in examining the effects of music during interval exercise protocols that may be more practical (i.e., reduced intensity and/or duration of work bouts) for general use (Stork et al., 2019).

Practical model of HIIT

Little et al., (2010) first introduced a more practical model of HIIT (10 x 60s bouts at 100% peak power, separated by 75s low intensity [30W] recovery) that was considered less demanding and more tolerable than other, more intense, interval exercise protocols while remaining time efficient. In a scoping review of psychological responses to interval exercise by Stork et al., (2017), a majority (69.1%) of the 55 interval exercise protocols included were classified as HIIT, and the most commonly studied interval exercise protocols were practical HIIT protocols consisting of 8-10 x 60s bouts separated by 60-90s recovery periods.

Aims and Hypotheses

Current evidence regarding the effects of music applied during interval exercise demonstrates some utility of continuous and respite music. However, further understanding of which application is most beneficial for positively enhancing affective responses (reported during and postexercise) to a practical HIIT session is required. A greater understanding would benefit researchers and practitioners by providing insight into how the effects of music during interval exercise could be maximised.

The aims of the present study were: 1) to examine whether listening to music during a practical HIIT session could positively influence pleasure and enjoyment, and 2) to determine whether continuous or respite music was more efficacious in terms of influencing these responses. Given the reduced attentional capacity to process external stimuli during high-intensity exercise and previous findings that the effects of music on pleasure during SIT work bouts were nonsignificant (Stork et al., 2015), it was hypothesised that pleasure would not differ between music and no-music conditions during the work bouts of the HIIT session (H_1). Based on previous evidence (Jones et al., 2017; Stork et al., 2015), it was anticipated that the music conditions would elicit greater pleasure during the recovery periods of practical HIIT session than the control condition (H_2). Finally, it was hypothesized that the application of music would result in greater enjoyment and more positive remembered pleasure in comparison to the no-music control condition (H_3).

Methods

The study received approval from the faculty ethics committee at Sheffield Hallam University, and all participants provided written informed consent.

Stage 1: Music Selection

The music preferences of a representative group of participants (*N* = 48, M_{age} = 21.77 ± 1.95) were collected by asking them to report their three favoured tracks for interval exercise. From this initial pool of tracks, the two most popular genres of tracks reported were Electronic Dance Music (EDM) and Grime/Hip-Hop. Thirty tracks from these genres (15 EDM and 15 Grime/Hip-Hop) were selected based on their tempo (120-140bpm) and other musical qualities (e.g., lyrical affirmations; see Karageorghis & Jones, 2014; Karageorghis & Priest, 2012b). Subsequently, these 30 tracks were rated by an additional 10 participants using the Brunel Music Rating Inventory-3 (Karageorghis, 2008) to provide a motivational quotient for each track. The 9 most motivational tracks from each genre were then selected for the experimental trials. All tracks were scored over 29 on the BMRI-3 indicating at least moderate motivational qualities. A similar music selection and implementation procedure was conducted in previous music and exercise studies (e.g., Karageorghis, Jones, & Stuart, 2008) and permits experimental participants a choice of musical genre during exercise while ensuring a theoretically-guided motivational music selection. All participants recruited for Stage 1 were of a similar demographic to participants recruited for Stage 2.

Stage 2: Experimental Trials

Study design. A repeated-measures crossover design was used with each participant completing three different exercise trials: continuous music (CM), respite music (RM) and no-music control (CON). The order of exercise testing was randomized and counterbalanced using a Williams Square design (Williams, 1949).

Participants. An *a priori* power calculation based on Feeling Scale responses was conducted in accordance with an effect size reported by Jones et al., (2017). The power calculation comprised, η_p^2 = 0.38, an alpha level of .05, power at 0.80, and indicated that 15 participants would be required. Eighteen participants (10 men and 8 women; M_{age} = 25.1±5.1 years; M_{BMI} = 23.08±2.01kg/m^2; *M* $\text{VO}_{2\text{max}}$ = 38.82±10.73ml/kg/min^{-1}) were recruited to allow for a counterbalanced design. Participants were of normal weight, recreationally active, and reported no health contraindications.

Apparatus. Participants exercised on a Lode Excalibur cycle ergometer for all sessions. Respiratory data were collected on a breath-by-breath basis using an online gas analyzer (Ultima, Medical Graphics) during the maximal test only. HR was monitored continuously using a Polar H10 HR strap and recorded on the Polar Beat application throughout all sessions. During the experimental conditions, music was played from a laptop computer connected to over-ear headphones (Sennheiser HD201) at a standardised sound intensity (75 dBA). Standardization of the sound intensity was conducted prior to participants wearing headphones.

Measures. Affective valence was measured using the Feeling Scale (FS; Hardy & Rejeski, 1989). The FS is a single-item scale with responses to "How do you currently feel?" ranging from -5 (*very bad*) to +5 (*very good*). The FS has been administered as a measure of core affective valence in a large number of studies (e.g., Hutchinson & O'Neil, 2019; Williams et al., 2008) and has been described as an appropriate measure for this construct (Ekkekakis & Zenko, 2016). The scale has demonstrated satisfactory validity (Hardy & Rejeski, 1989). Core affect has been defined as "the most elementary consciously accessible affective feeling" (Russell & Feldman-Barrett, 1999, p. 806); it is not about a specific object, and is free of cognitive appraisal (Ekkekakis, 2013). Enjoyment was measured postexercise using the Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991). PACES has been commonly administered as a measure of an emotional response following exercise (e.g., Stork et al., 2015; Zenko et al., 2019). PACES has been shown as a valid measure of exercise enjoyment (Kendzierski & DeCarlo, 1991). Differing from core affect, emotions result from the cognitive appraisal of a specific situational stimulus. Cronbach alpha values of PACES for the present study were 0.94 (CON), 0.94 (CM), and 0.89 (RM).

Remembered Pleasure was measured using a visual analogue scale (VAS) anchored by the descriptors "very unpleasant" (-100) and "very pleasant" (+100); participants were asked to respond to the question "How did the exercise session make you feel?" and they could respond using any integer between -100 and 100.VAS scores have shown reproducibility and validity in other domains (e.g., pain research) where VAS is considered gold standard (Yarnitsky et al., 1996). The reliability and validity of VAS to measure core affect has previously been shown (e.g., Monk, 1989). Remembered pleasure has been included in recent studies examining affective responses to exercise (e.g., Zenko et al., 2016) as an operationalisation of the concept of Remembered Utility in behavioural economics (e.g., Kahnemann, Wakker, and Sarin, 1997). Remembered pleasure is proposed to be a salient predictor of future exercise behaviour (Hutchinson et al., 2018) based on the memories of “affect-laden experiences” (Rozin, 2002, p. 847).

Procedure. Participants were required to visit the laboratory for testing on four separate occasions, with each visit separated by at least 48 hours and no more than 7 days.

Visit 1. The initial visit included a maximal aerobic capacity test to exhaustion (i.e., a VO_{2max} test). The VO_{2max} test protocol began with a 4 min warm-up at 50W followed by an increase to 75W at the start of the ramped protocol. Wattage (W) increased continuously throughout the protocol by a total of 20W each minute. The VO_{2max} test was used to determine HRmax and maximal power output (Wmax). Visit 1 also included a detailed explanation of the HIIT protocol and concluded with participants selecting a music genre (identified in Stage 1; either EDM or Grime/Hip-hop) to listen to during the subsequent experimental conditions.

Visits 2-4. Participants were required to complete a practical HIIT protocol during the subsequent three visits. The protocol comprised a 2-min warm up (30W) followed by 10 x 60s efforts at 100% Wmax separated by 75s recovery (30W), as employed by Little et al.,

(2010) and followed by a 2-min cool down. FS responses were recorded immediately prior to the warm up, during the final 15s of each work bout and recovery period, and immediately following the cool down. Participants completed the VAS for Remembered Pleasure and the PACES immediately after dismounting the cycle ergometer. The same protocol was followed for each exercise condition with the only difference being the auditory stimulus applied for each condition.

Conditions. For the CM condition, music started playing at the commencement of the first work bout and stopped at the end of final (10^{th}) work bout. The RM condition comprised music being played during the nine recovery periods only. The 75s RM clips included a verse and chorus. During the CON condition, participants wore headphones but no music was played.

Data Analyses

%HRmax and FS responses recorded during the work bouts were averaged to reduce issues of multiplicity within the analysis and in accordance with the *a priori* power analysis. Similarly, %HRmax and FS responses recorded during the recovery periods were averaged. Mean %HRmax achieved during the work bouts and mean %HRmax recorded during recovery periods were analysed using separate repeated measures ANOVAs. FS responses at baseline, averaged responses during work bouts, and postexercise were analysed using a 3 (Condition) x 3 (Time) repeated measures ANOVA. FS responses at baseline, averaged responses during the recovery periods, and postexercise were analysed using a 3 (Condition) x 3 (Time) repeated measures ANOVA. The postexercise measures of PACES and remembered pleasure were analysed using a repeated measures MANOVA with a Bonferroni corrected p value of .025 for step-down F tests. When significant effects were detected, post hoc pairwise comparisons using Bonferroni corrections were used to examine differences. Significance was set at $p < .05$ unless stated otherwise.

Results

There were no univariate or multivariate outliers and data met assumptions underpinning the analyses. Adjusted *F* tests are reported in instances where the assumption of sphericity was not met.

Manipulation Check: Exercise Intensity (%HRmax)

There were no significant differences between conditions for mean %HRmax during the work bouts, $F(2, 34) = 2.517$, $p = .096$, $\eta_p^2 = .13$. Similarly, there were no significant differences between conditions for mean %HR recorded during the recovery periods, $F(2, 34) = .50$, $p = .611$, $\eta_p^2 = .03$. Taken together, the HR data verified that there were no significant differences in exercise intensity across the three conditions. Overall, the mean HR from the onset of the first work bout to the end of the final work bout (including all recovery periods) was 79.20 ± 4.27 %HRmax across conditions. The mean HR for work bouts was 80.13 ± 4.28 %HRmax. The mean Wmax achieved during the VO_{2max} test was 289 ± 60.26 W. Table 1 includes %HRmax data for each work bout and recovery period.

Pleasure

Analysis of FS responses at baseline, during work bouts, and postexercise showed a main effect of time, $F(2, 34) = 11.084$, $p < .001$, $\eta_p^2 = 0.40$, with post-hoc tests indicating differences between the averaged responses during the work bouts and postexercise (work bouts < postexercise; $p < .001$, $d = 1.17$, Figure 1a). There was no main effect of condition, $F(2, 34) = .752$, $p = .479$, $\eta_p^2 = 0.04$, or interaction effect, $F(4, 68) = .416$, $p = .796$, $\eta_p^2 = 0.02$.

Analysis of FS scores at baseline, during recovery periods, and postexercise revealed no interaction effects, $F(4, 68) = 1.054$, $p = .386$, $\eta_p^2 = .06$, no main effect of condition, $F(2, 34) = 1.326$, $p = .279$, $\eta_p^2 = .07$, and no main effect of time, $F(1.289, 21.916) = 3.746$, $p = .057$, $\eta_p^2 = .18$ (Figure 1b).

Postexercise measures

Multivariate analysis indicated a significant omnibus effect for condition (Pillai's Trace = .31, $F(4, 68) = 3.11$, $p = .021$, $\eta_p^2 = .16$). Step-down *F* tests are presented for each measure.

Enjoyment. Analysis of PACES revealed a significant difference between conditions, $F(2, 34) = 4.22$, $p = .023$, $\eta_p^2 = 0.20$. Follow-up pairwise comparisons indicated that enjoyment was greater for CM ($M = 96.61 \pm 15.27$) compared to CON ($M = 86.89 \pm 14.37$; $p = .032$, $d = 0.66$), but no significant differences were detected between CON and RM ($M = 96.06 \pm 12.14$; $p = .095$, $d = 0.68$), or CM and RM conditions ($p = 1.00$, $d = 0.04$).

Remembered Pleasure. Analysis revealed a significant effect for Condition, $F(2, 34) = 4.22$, $p = .023$, $\eta_p^2 = 0.20$. Follow-up pairwise comparisons indicated that Remembered Pleasure was more positive in the CM condition ($M = 56.78 \pm 32.28$) compared to CON ($M = 35.61 \pm 50.73$; $p = .044$, $d = 0.50$), but no significant differences were detected between CON and RM ($M = 48.72 \pm 43.00$; $p = .324$, $d = 0.28$), or CM and RM conditions ($p = .688$, $d = 0.21$).

Discussion

The purpose of the present study was to examine whether listening to music during a practical HIIT session could positively influence pleasure and enjoyment, and to determine whether CM or RM had a greater influence. The results from this study indicated that, when compared to CON, listening to music continuously throughout the interval session elicited greater enjoyment and remembered pleasure. This is the first study to investigate the application of music during a 10 x 60s practical HIIT protocol and to differentiate the effects of CM versus RM during interval exercise.

Pleasure

In line with expectations (H_1), the present findings indicated no significant differences in FS scores during the work bouts between the experimental and control conditions. This finding is in line with previous research (Stork et al., 2015) and the capacity of music to influence pleasure during high-intensity interval work bouts appears limited, based on the few studies to date. Theoretical perspectives, such as that of Rejeski's (1985) parallel processing model, suggest that external stimuli (e.g., music) are less likely to reach focal awareness during high-intensity exercise as there is insufficient attentional capacity to process external stimuli as internal cues predominate. The present results indicate that the high-intensity work bouts of practical HIIT might be too intense to allow processing of external stimuli to an extent that meaningfully influences pleasure during the work bouts.

It was hypothesised that the music conditions would result in greater pleasure during the recovery periods compared to CON (H_2). The present findings refute this hypothesis as the "affective rebound" experienced following each work bout was not augmented by either application of music. The phenomenon of "affective rebound" or hedonic reversal, is known to occur when an individual experiences "significant departures from affective equilibrium" (Solomon & Corbit, 1974, p. 143) and has been shown in an exercise context when individuals engage in, and then cease, heavy or severe intensity exercise (Ekkekakis, Hall, & Petruzzello, 2005). It appears that the use of respite music during shorter recovery periods (75s) was less effective at enhancing pleasure during recovery than the respite music applied during longer recovery periods (180s) in the Jones et al., (2017) study. It is possible that a duration of 75s is insufficient for respite music to have an additive effect to the frequently reported affective rebound during HIIT studies (Decker & Ekkekakis, 2017).

The significant difference in pleasure found between the work bouts (1.45±1.33) and postexercise (3±1.31) is in line with previous work (e.g., Stork, Gibala, & Martin Ginis, 2018) and is also consistent with affective rebound. The decline in pleasure from baseline (2.20±1.39) to during work bouts was not statistically significant (p = .147) but was associated with a medium effect size (*d* = .55). Overall, the FS findings suggest that music may have a limited capacity to positively change the affective experience during HIIT.

Enjoyment and Remembered Pleasure

Affective responses recorded postexercise indicated that the CM condition was the most enjoyable and resulted in more positive remembered pleasure compared to CON, which partially supports H_3. Music has previously been shown to increase enjoyment of HIIT and SIT session (Stork et al., 2015; Stork et al., 2019), but the ineffectiveness of RM to increase enjoyment and remembered pleasure went against predictions.

It has been proposed that music evokes an emotional response through two routes (Scherer & Zentner, 2001): central (concerning the central nervous system) and peripheral (direct effects of the peripheral nervous system). Further, Scherer & Zentner (2001) identified three underlying mechanisms by which music can evoke emotions via the central route: (1) appraisal of music in relation to an individual's needs, goals, and values; (2) memories associated with a musical piece; (3) empathy elicited through observation of another person being affected. The longer exposure to music in the CM condition compared to RM might have allowed greater opportunity for music to elicit an emotional response. It is possible that participants had positive memories of specific music tracks, and their responses were influenced by the emotional salience of the memories associated with the music tracks, rather than the exercise, when recalling the session.

In-Task versus Post-Task Findings

It is proposed that the different affective constructs being measured (i.e., enjoyment as an emotion, rather than pleasure/displeasure as core affect) is the basis for the differentiated responses from *during* the HIIT session to afterwards. The FS (employed in-task) purports to measure the valence dimension of core affect ("the most elementary consciously accessible affect feelings [and their neurophysiological counterparts] that need not be directed at anything"; Russell & Feldman-Barrett, 1999). PACES is a measure of enjoyment – an emotion – and emotions are directed at a stimulus, require appraisal, are of short duration but high intensity, and comprise multiple components (Ekkekakis, 2013). Thus, the role of appraisal in the measurement of enjoyment is likely a key determinant for finding differences in affective responses after the exercise session, but not during.

There is evidence to suggest that subjective appraisals of how important exercise is to an individual can bias how positively they recall an exercise bout (Karnaze et al., 2017). The more an individual appraises exercise as important, the more they tend to overestimate how positive they felt during an exercise session. As the current sample were recreationally active, it seems reasonable to assume that they appraised exercise as being important. Therefore, the value participants placed on exercise might have biased their recall of what they felt during the HIIT session; this may have led to more positive responses to post-task (PACES) compared to in-task (FS) measures.

Implications and Future Research

An implication of this study is that practitioners could employ music continuously during practical HIIT sessions to enhance enjoyment and remembered pleasure. Strategies that serve to positively influence enjoyment and remembered pleasure could be useful for increasing the likelihood that an individual engages in exercise behaviour. Continued investigation into the role that in-task and post-task affective responses have on future exercise behaviour is required to further understand the role that music might play in positively influencing adherence to HIIT protocols.

Although the workload of the work bouts was standardised at 100%Wmax in this study, %HRmax data indicated that cardiorespiratory demand of the bouts increased as the session progressed (Table 1). The change in physiological demand from ~70%HRmax at the first bout to ~85%HRmax during the final bout highlights a possible consideration for applying strategies to influence affective responses during interval exercise. It is plausible that there is greater availability of cognitive resources (e.g., attentional capacity) earlier in HIIT sessions (e.g., work bouts 1-3) because the physiological demands are lower. Consequently, external stimuli designed to positively enhance affective responses might be more effective if applied during the earlier stages of a HIIT session (e.g., work bouts 1-3) compared to later bouts and future research could explore this further.

Strengths & Limitations

A strength of the current study was the use of a theoretically-guided music selection process to identify suitable music for the participants and interval exercise, while also allowing for participant choice. Further, the present study utilized rigorous methodology and accounted for common issues in the literature by following key considerations and recommendations from Stork et al., (2017). For instance, detailed procedural instructions were provided to participants; exercise sessions were separated by at least 48 hours; appropriate, valid, and reliable psychological measures were administered; FS scores were measured during the final 15s of each work bout and recovery period of HIIT; and a well-studied 10 x 60-s HIIT protocol was investigated due to its practicality and the potential for comparison across studies.

A limitation of the present study is that participants were young, healthy, and recreationally active. As a result, the findings may not generalize to physically inactive people or individuals living with chronic diseases (e.g., obesity, type 2 diabetes). Given that much of the ongoing debate about interval exercise centres around its suitability for less active populations, and existing evidence indicates that insufficiently active people experience more negative in-task affective responses to HIIT than active people (e.g., Frazão et al., 2016), there is merit in determining the capacity for music to positively influence affective responses to HIIT among low active participant samples. In addition, the HIIT sessions were completed in a standardized laboratory environment and only three single sessions of HIIT were completed by each participant over the course of this study. Thus, the ongoing effects of listening to music during HIIT in a naturalistic setting cannot be determined from the present findings. Future studies should investigate the longitudinal effects of music during HIIT in settings outside of the laboratory.

In the present study, the suggestions made about the relationship between attentional focus and pleasure were based on extant theoretical and empirical research. However, there was no direct measurement of attentional focus during work bouts, meaning the link between attentional focus and affective responses during HIIT were not directly assessed. Researchers might consider directly assessing attentional focus during HIIT work bouts in future studies.

The rigorous music selection process for the present study followed recommended guidelines (Karageorghis & Priest, 2012b), and similar procedures as previous work (e.g., Karageorghis & Jones, 2014). This approach ensured that the selection of motivational music was theoretically guided, while also allowing study participants to self-select a musical genre of their preference. Although this approach was taken to maximize the motivational qualities of the music, it was not possible to standardize individual responses to the music played during the HIIT sessions. It is possible that some of the findings were, in part, due to a lack of motivational response elicited on an individual level.

Conclusion

This study provided new evidence that listening to music continuously throughout a practical HIIT session can positively influence enjoyment and remembered pleasure. However, the application of continuous or respite music did not significantly influence pleasure during the work bouts or recovery periods of a practical HIIT session. Listening to theoretically-driven motivational music continuously throughout a practical HIIT session is a useful and easily implementable strategy for positively influencing enjoyment and remembered pleasure, and might have implications for continued HIIT behaviour.

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Table 1.

Descriptive statistics (M±SD) for %HRmax and Feeling Scale across work bouts and recovery periods

	%HRmax			Feeling Scale		
	CON	CM	RM	CON	CM	RM
Baseline				2.17±1.50	2.28±1.32	2.17±1.34
W1	70.87±4.40	71.45±4.23	69.28±5.14	1.56±1.62	1.67±1.08	1.94±1.47
R1	70.16±5.71	70.19±4.56	69.85±7.10	2.39±1.20	2.33±1.28	2.56±0.98
W2	75.64±5.33	76.23±3.80	74.80±6.31	1.61±1.46	1.78±1.35	1.83±1.29
R2	72.93±7.10	73.62±5.33	72.86±7.67	2.28±1.27	2.78±1.06	2.78±1.11
W3	78.25±5.78	78.81±4.32	76.84±6.57	1.72±1.32	1.94±1.30	1.83±1.25
R3	76.66±6.84	76.76±5.70	75.69±7.77	2.28±1.13	2.72±1.13	2.94±1.00
W4	80.12±5.78	80.63±4.58	78.85±6.53	1.67.1.57	1.78±1.44	1.94±1.16
R4	78.71±6.74	78.19±6.10	77.41±8.21	2.22±1.22	2.39±1.24	2.94±1.11
W5	81.63±6.06	81.96±4.61	80.10±6.48	1.61±1.69	1.61±1.09	1.72±1.32
R5	80.39±6.44	79.69±5.94	78.94±7.98	2.39±1.24	2.44±1.04	3.11±1.02
W6	82.58±6.18	82.83±4.63	80.71±6.68	1.17±1.58	1.67±1.53	1.56±1.20
R6	80.72±7.13	80.69±6.17	79.98±8.53	2.28±1.56	2.44±0.92	3.06±1.30
W7	82.97±6.04	83.66±4.79	81.56±6.97	0.94±2.13	1.67±1.24	1.33±1.46
R7	81.90±6.64	81.52±6.32	80.86±8.45	1.89±2.00	2.39±1.33	2.72±1.27
W8	83.59±6.16	84.13±4.88	82.28±7.02	0.50±2.38	1.33±1.64	1.50±1.62
R8	82.20±7.41	82.40±5.95	81.06±8.79	1.67±2.11	2.33±1.28	2.78±1.17
W9	84.40±6.20	84.35±5.21	82.47±6.87	0.56±2.75	1.28±1.87	1.44±1.95
R9	82.87±7.03	82.31±6.83	81.94±7.83	1.56±2.50	2.28±1.27	2.56±1.54
W10	84.93±6.15	85.14±5.28	82.72±6.74	0.56±2.83	0.83±1.79	1.00±1.91
Post				2.83±1.65	3.00±1.08	3.17±1.20

%HRmax = percentage of maximal heart rate, CON = control, CM = continuous music, RM = respite music, W = work bout, R = recovery period.

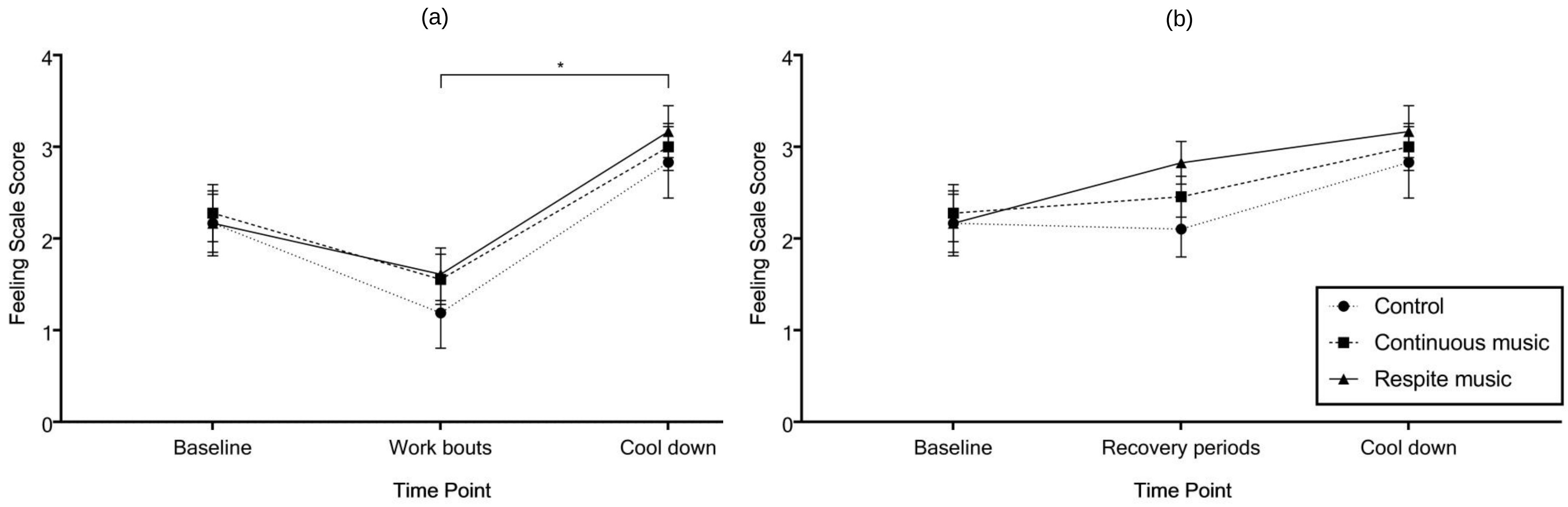

Figure 1. Feeling Scale scores (*M*±*SE*) recorded at baseline, during work bouts, and cooldown (a). Feeling Scale scores recorded at baseline, during recovery periods, and cooldown (b). * = $p < .001$.