Effects of Music on Cycling

Lim, H. B., Karageorghis, C. I., Romer, L. M., & Bishop, D. T. (2014). Psychophysiological effects of synchronous versus asynchronous music during cycling. *Medicine & Science in Sports & Exercise*, *46*, 407–413.

Psychophysiological Effects of Synchronous versus Asynchronous Music during Cycling

Running Head: Psychophysiological Effects of Music during Cycling

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This research was not funded and the authors have no conflicts of interests to declare.

ABSTRACT

Purpose: Synchronizing movement to a musical beat may reduce the metabolic cost of exercise, but findings to date have been equivocal. Our aim was to examine the degree to which the synchronous application of music moderates the metabolic demands of a cycle ergometer task. **Methods:** Twenty-three recreationally active men completed two laboratory visits. During the first visit, participants completed a maximal incremental ramp test on a cycle ergometer. At the second visit, they completed four randomized 6-min cycling bouts at 90% of ventilatory threshold (control, metronome, synchronous music, asynchronous music). Main outcome variables were oxygen uptake, HR, ratings of dyspnea and limb discomfort, affective valence, and arousal. **Results:** No significant differences were evident for oxygen uptake. HR was lower under the metronome condition (122 ± 15 bpm), compared to asynchronous music (124 ± 17 bpm), and control (125 ± 16 bpm). Limb discomfort was lower while listening to the metronome (2.5 ± 1.2), and synchronous music (2.3 ± 1.1), compared to control (3.0 ± 1.5). Both music conditions, synchronous (1.9 ± 1.2) and asynchronous (2.1 ± 1.3), elicited more positive affective valence compared to metronome (1.2 ± 1.4) and control (1.2 ± 1.2), while arousal was higher with synchronous music (3.4 ± 0.9) compared to metronome (2.8 ± 1.0) and control (2.8 ± 0.9). **Conclusion:** Synchronizing movement to a rhythmic stimulus does not reduce metabolic cost but may lower limb discomfort. Moreover, synchronous music has a stronger effect on limb discomfort and arousal when compared to asynchronous music.

Keywords: economy, exercise, pleasure, RPE, tempo

INTRODUCTION

Researchers who have addressed the role of music in exercise and physical activity contexts have typically disregarded the degree to which movement and music are in synchrony; this is despite good evidence for our inherent tendency to synchronize movements with a strong musical beat (37). The application of music can be either synchronous, where there is conscious synchronization between the rhythmical components of music (e.g., tempo) and an individual's movement patterns, or asynchronous, where there is no conscious attempt from the individual to match their movements with the rhythmical qualities of the music (14). What is currently unknown is whether the effects engendered by synchronous music are different to those engendered by asynchronous music.

Recent research evidence indicates that synchronizing movement patterns to an external rhythmic auditory stimulus (RAS) such as music could possibly lead to reduced metabolic cost via enhanced neuromuscular or metabolic efficiency (15, 16, 31); the neural circuitry for such sensorimotor synchronization has been recently identified (22). Moreover, an auditory stimulus has been shown to enhance spinal motor neuron excitability and subsequent motor readiness before supraspinal input (25) — a likely physiological explanation for the arousing properties of music. An auditory rhythm is also known to create a point of reference that is able to attract and swiftly entrain recurring motor patterns (25, 33). Thus, there appears to be a sound neurophysiological basis underpinning the notion that movement-music synchrony can confer a physiological advantage.

People appear to have a preferred frequency for repetitive and cyclic movements (28), which has been termed the *resonant frequency* of the muscle-limb system (10); Kenyon and Thaut (19) proposed the existence of an *internal time keeper* that plays a role in the modulation and maintenance of this behavior. Nonetheless, the precision of this internal timing mechanism has been found to vary not only across individuals, but also intra-individually (28). Thus, if the period of an individual's movement varies from one repetitive phase to the next, it is highly likely that the kinematics of the movement would also exhibit similar variability (19). By providing a precise time reference such as a RAS, an individual's internal timing mechanism, and by extension the kinematic parameters of their movements, can be fine-tuned. More consistent and smoother movement patterns would imply a greater level of efficiency, leading to reduced metabolic cost of movement (19).

Provision of a RAS such as music or a metronome has been shown to enhance patients' rehabilitation in numerous neuromotor disorders compared to conventional therapy. Gait patterns and muscle activation patterns have been shown to improve patients with Parkinson's disease (21) and those who had stroke (34). Positive changes have also been observed in stroke patients undergoing paretic arm training (19, 32), suggesting that synchronization may facilitate all movement patterns, not just those that are inherently rhythmic in nature, such as walking.

Bacon et al. (1) investigated the effects of movement-music synchrony on metabolic efficiency during submaximal cycling; exercise intensity and movement frequency were fixed. Results indicated that oxygen consumption under synchronous music was lower when compared to a slow asynchronous music condition, which the authors interpreted as being indicative of improved economy. There were several methodological limitations that might have confounded their findings. First, the absence of a no-music control trial prohibited conclusions about the benefits of synchronous music relative to the maintenance of cadence without an external rhythmic cue. Second, exercise intensities were set arbitrarily at a percentage of maximal capacity. Such a method of exercise standardization does not give an accurate representation of one's metabolic responses as 70% might be above the lactate threshold for some individuals or below for others (18). Perhaps a more appropriate method of standardizing exercise intensity would be to set it relative to ventilatory threshold (VT) as this provides a more accurate indication of the contributions made by aerobic and anaerobic metabolic processes (35).

Researchers have generally assumed that the psychological effects of synchronous music are derived through the same processes as those proposed for asynchronous music (15, 16). However, owing to a dearth of research that relates these two broad music classifications, any differences in their psychophysiological effects are unknown. Accordingly, the aim of the present study was to investigate the psychophysiological effects of asynchronous and synchronous music during submaximal cycling. We hypothesized that (a) under metronome and synchronous music conditions, participants would elicit lower $\dot{V}O_2$ when compared to asynchronous music and a no-auditory control; (b) participants would report more positive affective valence and higher levels of subjective arousal from both music conditions compared to the metronome and control conditions; and (c) cycling under any form of auditory stimulus would result in lower perceived symptoms in comparison to control.

METHOD

Power analysis

An appropriate sample size was determined using power analysis software (G*Power 3.1.2; Dusseldorf University, Dusseldorf, Germany). With α set at 0.05, power at 0.8 to protect β at four times the level of α (5), intercorrelation for repeated-measures at 0.5, sphericity correction at 1, and an estimation of a moderate effect size (d = 0.60) to detect the effects of synchronous music (1, 27), we determined that 24 participants would be required for the study.

Participants

After obtaining institutional ethics committee approval and written informed consent, 24 recreationally active men volunteered to participate (mean ± SD age = 22 ± 4 years, mass = 74.2 ± 11.4 kg, stature = 178.8 ± 6.8 cm). All levels of cycling ability were accepted as this was not expected to affect the results owing to the use of a repeated-measures design.

Experimental design

Participants visited the laboratory on two occasions that were separated by at least 48 h. The purpose of the first visit was to establish participants' VT and maximum oxygen uptake ($\dot{V}O_{2max}$) and to familiarize them with the cycle ergometer and exercise protocol. The level of exercise intensity was set in relation to the VT. An exercise intensity of 90% VT was chosen as this represents moderate exercise whereby physiological responses are expected to reach a steady state.

The second visit comprised the experimental phase. Participants completed four cycling bouts under four conditions: 1) no-music control; 2) synchronous metronome (150 bpm); 3) synchronous music (150 bpm); and 4) asynchronous music (170 bpm). Participants maintained a cycling cadence of 75 rpm throughout each bout; a full pedal revolution occurring regularly at 75 rpm was performed in synchrony with a tempo of 150 bpm, with a semi-revolution of the pedals matching each beat of the music. Researchers have suggested that exercise durations should be at least 5 min when obtaining gas exchange data for the calculation of efficiency (12). Accordingly, it was decided that an exercise duration of 6 min would suffice for the purpose of the present investigation, given that exercise intensity was set at a submaximal intensity of 90% VT. Each exercise bout lasted 6 min and was separated by 6 min of rest.

Auditory stimuli

Two music tracks were selected: *I Fly In My Dreams* (156 bpm), and *The Power Of Sound* (156 bpm), both written by Australian composer Andrew Batterham and produced by Run2Rhythm (www.run2r.com). The rationale underlying this choice of music centers upon its relative obscurity among British music listeners. Thus, the influence of factors such as sociocultural background, age, and musical preferences was minimized (17, 24). Moreover, factors such as extramusical associations and cultural impact were negated because of the unfamiliar nature of the music. All potential participants were screened to ascertain that they had no prior knowledge of the musical selections.

I Fly In My Dreams was used for the experimental sessions, whereas *The Power Of Sound* was used for the familiarization trial. This decision was predicated on the fact that the former track has a more prominent beat. The tempo of each track was digitally altered without distorting the pitch using audio editing software (Audacity; audacity.sourceforge.net). The experimental track had two variants —150 bpm (synchronous condition), and 170 bpm (asynchronous condition) — whereas the familiarization track had the tempo altered to 150 bpm. An auditory metronomic tone of 150 bpm was created using specialized software (TempoPerfect Metronome Software; NCH Software Pty Ltd, Canberra, Australia). Auditory stimuli were delivered via loudspeakers, and a decibel meter (AZ 8928; AZ Instrument Corporation, Taichung City, Taiwan) was used to standardize sound intensity at 80 dBA.

Maximum oxygen uptake and familiarization.

An incremental ramp test was conducted on an electromagnetically braked cycle ergometer (Velotron; RacerMate Inc., Seattle, WA) to determine participants' $\dot{V}O_{2max}$. The same ergometer was also used for the experimental phase. Participants pedalled for 3 min at 30 W, after which there was a linear increase of 30 $W \cdot min^{-1}$ up to the point of exercise termination, which was defined as the point at which participants were unable to maintain a cycling cadence of 75 rpm for more than 10 s. Breath-by-breath ventilatory and pulmonary gas exchange data were recorded continuously during the incremental task using an online system (Quark b^2, Cosmed, Rome, Italy) and averaged over 10-s periods. HR was recorded every 5 s using a chest strap transmitter linked to a wristwatch (Polar S610i; Polar Electro Oy, Kempele, Finland). Maximum oxygen uptake was determined as the highest 30-s average value attained by the participant. Saddle and handlebar configurations were adjusted to each participant's requirements and the same configuration was used for the subsequent session.

To ensure that the $\dot{V}O_2$ obtained in the incremental ramp protocol was a true reflection of maximum oxygen uptake, an appended step test was conducted after a 10- to 15-min rest period (26). The highest 30-s average of $\dot{V}O_2$ of the incremental test or the appended step test was taken as the maximum value. VT was determined online using mixed parallel methods (35). The workload for the experimental trial (i.e., 90% VT) was calculated with consideration taken for the mean response time for $\dot{V}O_2$ during ramp exercise (i.e., two-thirds of the ramp rate was subtracted from the work rate at 90% VT) (36).

After the appended step test and a subsequent rest period of 10 min, participants were familiarized to the experimental task by requesting them to synchronize their pedal cadence with the track previously chosen for this purpose. They were also introduced to the psychological measurement tools: Borg's Category Ratio 10 (CR10) scale (3), Hardy and Rejeski's (9) Feeling Scale (FS), and the Felt Arousal Scale (FAS) of the Telic State Measure (29). The CR10 scale was used to assess perceptions of breathing discomfort (dyspnea) and limb discomfort. Participants were encouraged to rate naïvely without making judgments or evaluating the degree of correctness of their responses. The FS is an 11-point, single-item measure, with a scale ranging from –5 to +5, that was used to assess in-task affective valence. The FAS is a 6-point, single-item measure with a scale from 1 to 6 that was used to determine subjective levels of arousal.

Experimental phase

At least 48 h and a maximum of 7 d separated the initial visit from the experimental session. In the no-music control and asynchronous music conditions, participants maintained the prescribed pedal rate via a digital display screen. For the synchronous music and metronome conditions, participants were instructed to use the beats of the relevant auditory stimulus to maintain their pedal frequency. No visual feedback was provided in these instances. The pedal cadence was continuously recorded for each exercise bout and also monitored to ensure that any major deviations (± 2 rpm) from the prescribed cadence were immediately corrected. Respiratory and HR data were continuously recorded for the entire duration of each bout. Participants rated their perceptions of dyspnoea and limb discomfort, in-task affective valence, and arousal at 2-min intervals throughout each exercise bout by pointing to a number on the respective scale.

To minimize carryover effects, the order of conditions was randomly assigned and fully counterbalanced. Participants were asked to refrain from any form of vigorous physical exercise for 48 h before testing. They were also instructed not to consume products containing caffeine and alcohol, or food and drinks (except water) 12 and 3 h, respectively, before each visit.

Data analysis

Oxygen uptake and HR were measured continuously for the entire 6-min task duration. However, only the last minute was used in the analysis as it was considered an accurate reflection of steady-state exercise (12). Perceptual responses, in-task affective valence, and arousal were measured at 2, 4, and 6 min; the data for each variable were collated to give a mean value. Raw data were screened for univariate outliers using standardized scores ($-3.29 \leq z \geq 3.29$), while deviations from normality were examined using standard skewness and kurtosis (≥ 1.96). Tests were also carried out to ensure that the data met the relevant parametric assumptions. All dependent variables were analyzed using one-way repeated-measures ANOVA with Bonferroni adjustments. The α level was set at $P < 0.05$, and where necessary, univariate tests were corrected for sphericity violations using Greenhouse-Geisser-adjusted F values. Analyses were performed using SPSS for Windows Version 15 (SPSS, Inc., Chicago, IL).

RESULTS

Twenty four participants were recruited for the study, but only 23 completed the experiment as one withdrew after the first visit. Group mean $\dot{V}O_{2max}$ and work rate at 90%

VT were 46.8 ± 5.1 mL· kg^{-1}·min^{-1} and 129 ± 37 W, respectively. HR data for four participants were excluded from the analysis as the responses were deemed to be irregular.

Physiological responses

Condition had no significant effect on oxygen uptake (*P* = 0.523). Average $\dot{V}O_2$ for control, metronome, synchronous music, and asynchronous music was 23.6 ± 4.6, 23.4 ± 4.6, 23.5 ± 4.7, and 23.5 ± 4.8 mL· kg^{-1}·min^{-1}, respectively. Condition had a significant effect was observed for HR. Follow-up pairwise comparisons with Bonferroni adjustment indicated that HR was significantly lower in the metronome condition compared to asynchronous music (*P* = 0.028, *M* = –2 bpm, 95% confidence interval [CI] = –5, –0, *d* = 0.12) and no-music control (*P* = 0.011, *M* = –3 bpm, 95% CI = –7 to –1, *d* = 0.18). However, no significant differences in HR were observed between metronome and synchronous music conditions (*P* > 0.05). There were also no significant differences across the remaining three conditions (Fig. 1).

Perceptual responses

Condition had no main effect on dyspnea (*P* = 0.255). The mean ratings for control, metronome, synchronous music, and asynchronous music were 2.2 ± 1.0, 2.0 ± 1.1, 2.0 ± 1.1, and 2.1 ± 1.2, respectively. However, condition had a significant effect observed for limb discomfort (*P* = 0.001). Follow-up pairwise comparisons with Bonferroni adjustment indicated that participants in the metronome (*P* = 0.010, *M* = –0.5, 95% CI = –0.1 to –0.8, *d* = 0.29) and synchronous music conditions (*P* = 0.010, *M* = –0.7, 95% CI = –0.1 to –1.3, *d* = 0.45) reported significantly less limb discomfort when compared against the control condition. There were no significant differences for asynchronous music compared to all other conditions, and there were also no differences between the metronome and synchronous music conditions (Fig. 2).

Psychological responses

The effect of condition was significant for both in-task affective valence ($F_{3,66}$) = 9.51, *P* < 0.001, and arousal ($F_{3,66}$ = 4.78, *P* = 0.004. Follow-up pairwise comparisons with

Bonferroni adjustment indicated that in-task affective valence was significantly higher for both music conditions when compared to the metronome (P_{sync} = 0.008, *M* = 0.7, 95% CI = 0.2–1.3, *d* = 0.56, P_{async} = 0.005, *M* = 0.9, 95% CI = 0.2–1.6, *d* = 0.67) and no-music control (P_{sync} = 0.004, *M* = 0.7, 95% CI = 0.2–1.3, *d* = 0.61, P_{async} = 0.007, *M* = 0.9, 95% CI = 0.2–1.7, *d* = 0.72). Further, in-task affective valence did not differ between music conditions or between metronome and no-music control conditions (Fig. 3). In-task arousal was significantly higher in the synchronous music condition when compared against both metronome (*P* = 0.010, *M* = 0.6, 95% CI = 0.1–1.1, *d* = 0.63) and no-music control (*P* = 0.026, *M* = 0.6, 95% CI = 0.1–1.2, *d* = 0.67. Asynchronous music did not differ from the other three conditions (Fig. 4).

DISCUSSION

The results of the present study show that $\dot{V}O_2$ did not differ significantly across conditions, suggesting that synchronizing cycling frequency to music has no effect on energy efficiency during exercise below the VT. There were significant differences in perceived exertion, with the metronome and synchronous music conditions eliciting less limb discomfort when compared to asynchronous music and no-music control. Significant differences for both in-task affective valence and arousal also emerged: music conditions elicited higher levels of affective valence (i.e., more pleasant affect) compared to metronome and no-music control conditions, while participants were more aroused when listening to synchronous music when compared to the metronome and no-music control conditions.

Oxygen uptake and HR

Synchronizing movements to a RAS did not improve oxygen economy when compared to cycling under asynchronous music and no-music control conditions. This stands in contrast to findings reported in past studies (1, 31). The discrepancy may, in part, be due to differences in exercise intensity; previous studies used relatively high workloads (>70% HR_{max}) (1, 31). At such intensities, it is possible that participants faced difficulties maintaining a consistent technique owing to the increased workload. Accordingly, movement-music synchrony may be more effective at higher exercise intensities through assisting in the maintenance of a regular motor pattern.

Despite no influence on global energetics, synchronizing to a metronome did elicit a small but statistically significant decrease in HR when compared to cycling under conditions of asynchronous music and no-music control. Given that the metronome condition induced changes in heart rate, one would also have expected similar changes in response to synchronous music since both operate as rhythmic cues. It is possible that the melodic and harmonic qualities of music caused an increase in HR. Thus, any reduction in HR that might have resulted from synchronization with musical tempo could have been masked by the influence of these melodic and harmonic qualities. It is currently unclear precisely how these qualities of music might influence exercise HR. The reduction in HR noted in the metronome condition might have stemmed from a subtle decrease in energy expenditure consequent to an increase in the synchronization between locomotor and respiratory systems (11). Entrainment of respiratory frequency to movement frequency is a fairly common phenomenon (2, 13). Moreover, the presence of an external rhythmic cue has been shown to stabilize the breathing pattern (8). In the present study, however, cycling in synchrony with the metronome on had no effect on respiratory frequency or any other aspect of the breathing pattern (data not shown). Thus, it seems unlikely that synchronization was responsible for the observed reduction in HR.

Perceptual ratings

Auditory-motor synchronization affected dyspnea and limb discomfort differently. Provision of an auditory stimulus and/or synchronization did not influence dyspnea. Under RAS, however, participants reported significantly less limb discomfort compared to cycling in the no-music control condition. No significant differences were observed between metronome and synchronous music conditions. In addition, perceptual ratings during asynchronous music exposure did not differ from the other conditions; this indicates that asynchronous music did influence participants' symptom perceptions but that its effects were not as pronounced as those engendered by auditory-motor synchronization.

Collectively, the current findings indicate that the effects of synchronization are more effective in diverting internal sensations away from focal awareness than qualities of the music such as melody and harmony, at least for a 6-min exercise bout. Although reductions in limb discomfort were also reported by participants in response to asynchronous music, this did not differ significantly ($p > 0.05$) from the no-music control. Karageorghis et al. (15) suggested that synchronizing movement to RAS is a form of active attentional manipulation, whereas music listening generally functions as a passive attentional manipulation. Thus, it appears that active and passive attentional manipulations can have an additive effect when used in tandem, but musical properties such as harmony and melody appear to affect symptom perceptions to a lesser degree when contrasted with auditory-motor synchronization.

Affective valence and arousal

Both music conditions elicited more positive affective valence compared to metronome and no-music control conditions, whereas no differences were evident between the metronome and control conditions. This is in line with extant literature concerning both synchronous (15, 31) and asynchronous (4, 6) music; researchers have shown that listening to music, whether in the background or as a cue for rhythmic movement, enabled participants to derive more pleasure from an activity when compared to completing the same activity in silence. It has been proposed that the melodic and harmonic aspects of music are more likely to influence affective responses, while rhythmical elements affect bodily responses (20). This proposition is further corroborated by the current observation that the metronome condition, devoid of musical qualities other than tempo, did not elicit any increase in the pleasure experienced by participants. The direction and magnitude of changes in arousal were similar to those reported for in-task affective valence. Nonetheless, it was slightly surprising that only the synchronous music condition was significantly more arousing when compared to the metronome and no-music control conditions. No differences were noticed for the asynchronous music condition in relation to the other conditions. This would imply that asynchronous music exposure did have an arousing effect, but not to the same degree as synchronous music.

Limitations

It has been established that each individual has a preferred tempo for a given task, and that this varies from person to person (28). Accordingly, the imposition of a fixed pedal frequency meant that participants may have been cycling at a cadence that was not necessarily their preferred rate. This might have reduced their mechanical efficiency, as they were forced to adopt the prescribed pedal cadence. By way of illustration, elite cyclists favor a pedal cadence of ≥ 80 rpm (7), which is higher than the 75 rpm used in the present study; nonetheless, no elite cyclists were recruited for the present study. Another potential limitation pertains to the mismatch in terms of the processing of cues (visual vs auditory) to maintain the prescribed cadence. In the asynchronous music and no-music conditions, participants were presented with a visual display of their pedal frequency, whereas in the synchronous conditions, they were provided with an auditory stimulus. Nonetheless, if the aim of a study is to isolate the effects of auditory-motor synchronization, such a limitation is difficult to surmount.

A final limitation is that the results are only applicable to recreationally active males age 18–35 yr and may not extrapolate to other groups. For example, the influence and magnitude of differences associated with music use might differ for elite athletes, who tend to adopt associative, rather than dissociative, attentional strategies (23). Accordingly, the efficacy of music might be of a lesser order for such individuals.

Implications and future directions

Current findings suggest that the psychological and psychophysical effects of music differ in accordance with its mode of application; thus, a separate conceptual framework is required, or at least refinements made to current frameworks (i.e., [17, 30]), to more accurately detail the effects of movement-music synchrony in the realm of exercise and sport. The assessment of additional physiological parameters might also shed light onto possible efficiency gains that were not reflected in $\dot{V}O_2$. For example, patients with Parkinson disease (21) and hemiparetic stroke (32, 34) have significantly reduced variability and magnitude of EMG gait patterns when exposed to RAS—an indication of more consistent and efficient motor neuron recruitment. Future researchers may also wish to examine whether similar findings are evident for different exercise modalities such as running, rowing, and swimming. Such activities afford greater degrees of freedom in movement patterns compared to cycling, and would thus have greater scope for improvements in the kinematic chain. Research by Terry et al. (31) on the effects of synchronous music use during submaximal and exhaustive running does provide empirical evidence in support of this notion.

The present findings are potentially relevant to music use in exercise and sport contexts. The use of synchronous music could be considered for training sessions to enhance affective valence and reduce perceived exertion, but only when training indoors because of safety concerns. Exercise instructors involved with movement-to-music classes such as aerobics and spinning, who wish to bolster the adherence of exercisers, might consider the use of synchronous music over asynchronous music; auditory–motor synchronization appears to reduce fatigue-related symptom perceptions and increase arousal more readily when compared to listening to music in the background (asynchronously). This principle is equally applicable to recreational exercisers, in particular those who engage in endurance-based tasks or circuit-type training (15, 16).

CONCLUSIONS

Current observations suggest that cycling in synchrony with music or to a metronome tone lowers fatigue-related symptom perceptions compared to a no-music control. In addition, movement–music synchrony was the only experimental condition that significantly increased participants’ arousal levels. That this was not observed when participants cycled with asynchronous music suggests that auditory-motor synchronization interacts with the musical qualities in a manner that significantly increases participants’ arousal levels. The present findings, however, do not permit firm conclusions as to the mechanisms by which an accompanying rhythmic musical stimulus might enhance cycling performance, although reduced oxygen cost appears unlikely. Given the difference in findings between synchronous and asynchronous music application, there is a need for separate conceptual frameworks to detail the processes and responses associated with each of these two applications. In addition, exercise practitioners can use the current findings to make more informed choices on how music is applied in accordance with the type of activity they are leading, the target group, and the desired outcomes for the session.

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This research was not funded and the authors have no conflicts of interests to declare.

The results of the present study do not constitute endorsement by ACSM.

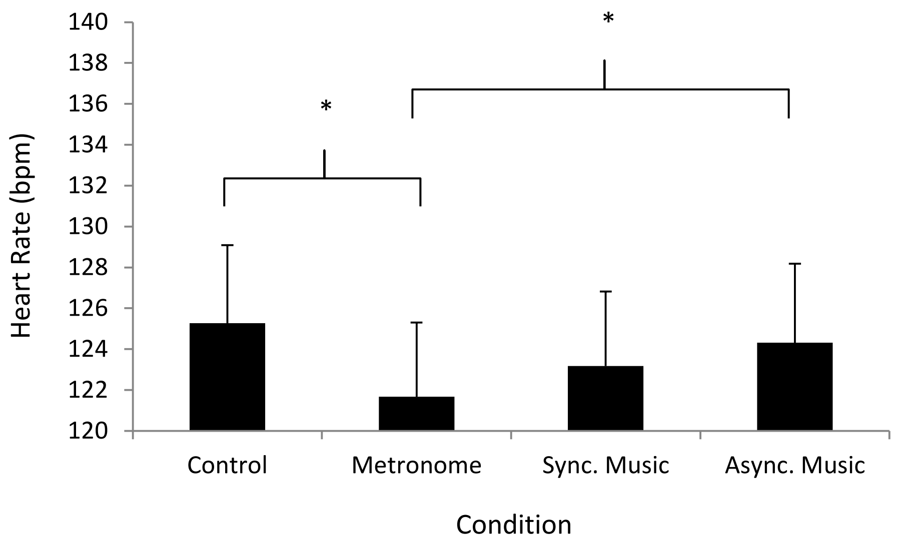

FIGURE 1—Means and SEs (T-bars) for HR under conditions of control, metronome, synchronous music, and asynchronous music.

***Significant differences between conditions, *P* < 0.05.**

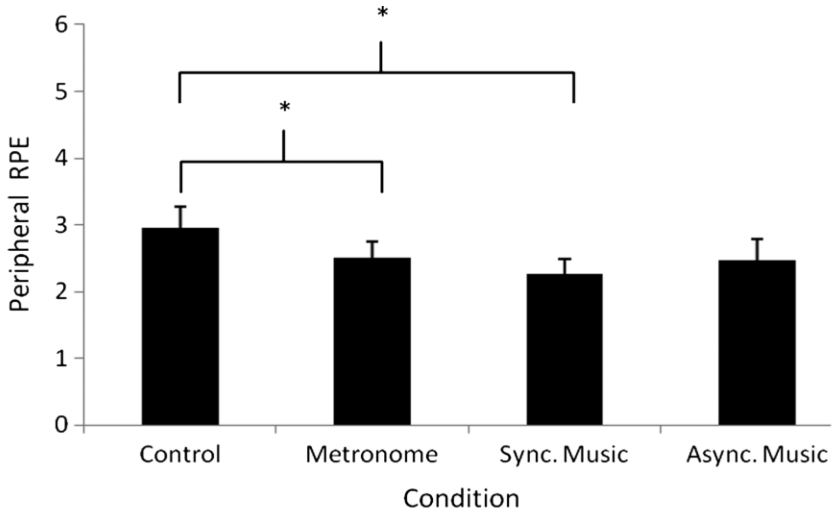

FIGURE 2—Means and SEs (T-bars) for peripheral RPE under conditions of control, metronome, synchronous music, and asynchronous music.

***Significant differences between conditions, *P* < 0.05.**

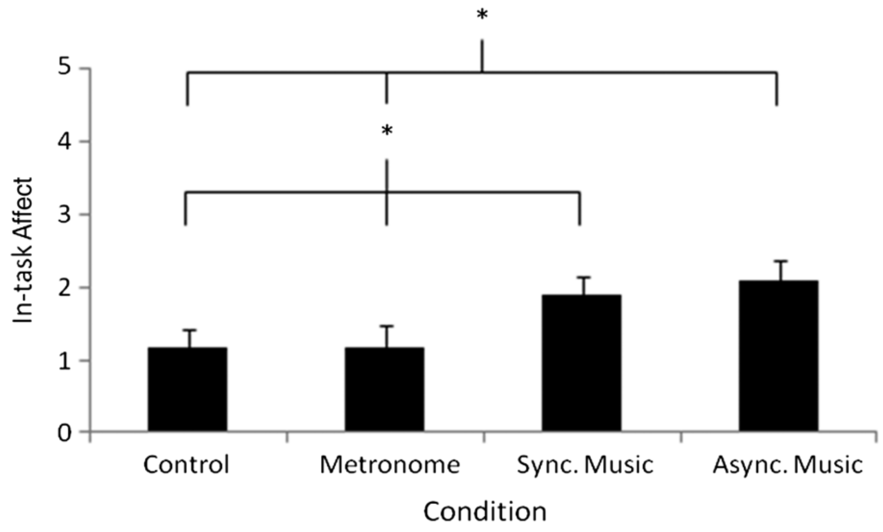

FIGURE 3—Means and SEs (T-bars) for in-task affect under conditions of control, metronome, synchronous music, and asynchronous music.

***Significant differences between conditions, *P* < 0.05.**

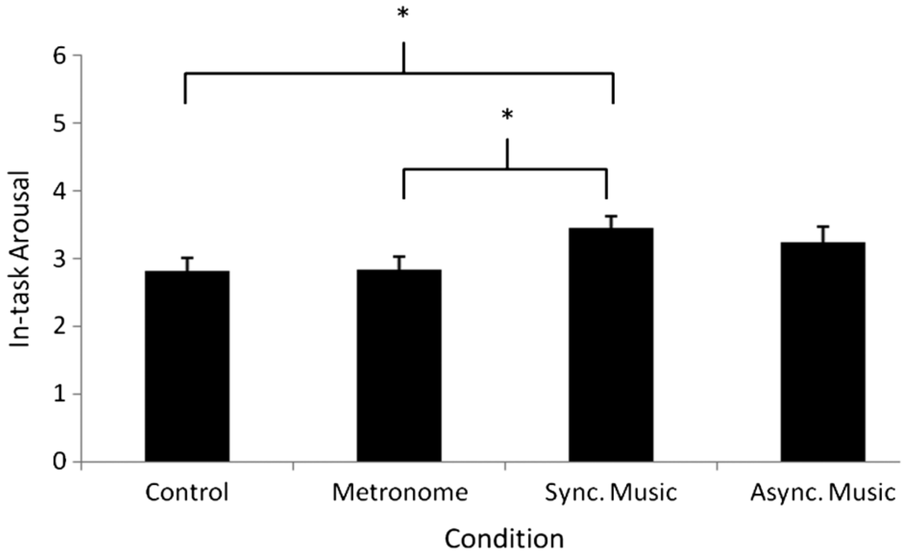

FIGURE 4—Means and SEs (T-bars) for in-task arousal under conditions of control, metronome, synchronous music, and asynchronous music.

***Significant differences between conditions, *P* < 0.05.**