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Music During Exercise: Does Tempo Influence Psychophysical Responses? Dave Elliott

Philica 2007

Abstract

This study was conducted with the assistance of Gretel Jackson, undergraduate of the University of Cumbria.

This study examined whether music of different tempi would influence the psychophysical responses of exercise participants performing a sub-maximal cycle task. Specifically, the investigation assessed the effect of musical tempo upon aerobic work rate and whether dissociation, and/or, arousal could be implicated in any physical responses. Eighteen student participants (10 females, 8 males) were required to partake in four experimental conditions: no music, 'slow' music, 'moderately fast' music, and 'fast' music. As a measure of exercise intensity, total distance travelled in 20-minute trial was measured; work rates were also expressed as average power output. Being indicative of dissociation, ratings of RPE and affect were taken. Measures of in-task arousal and degree of music liking were also examined. Findings revealed that both 'moderately fast' and 'fast' music resulted in a significant increase in exercise intensity when compared to the no music and 'slow' music conditions. No significant differences were evident between the no and 'slow' music trials. There was some evidence of dissociation in two of the music conditions. Whilst all music types produced an elevation in arousal, when compared to the control it was only in the 'slow' music condition that was deemed to be statistically significant. There was no significant difference between the music conditions. Thus, it appears that arousal had no impact upon exercise intensity. Ratings for 'liking' showed that all of the music types were received positively.

Introduction

Numerous investigations have shown that listening to music whilst performing aerobic exercise can produce ergogenic gains (Anshel & Marisi, 1978; Szabo, Small & Leigh, 1999; Elliott, Carr & Savage, 2004; Elliott, Carr & Orme, 2005). Despite support for the performance enhancing properties of music, the mechanisms responsible remain unclear. One possible explanation relates to music's ability to induce a state of dissociation. Dissociation occurs when an individual focuses upon external stimuli thereby reducing the perception of internal bodily cues; this response can be evidenced by reductions in RPE and improved affect (Rejeski, 1985; Boutcher & Trenske, 1990). Numerous investigators have made reference to music's dissociative capability (Anshel & Marisi, 1978; Boutcher & Trenske, 1990; Brownly, McMurray, & Hackney, 1995; Szabo, Small & Leigh, 1999; Hayakawa, Miki, Takada, & Tanaka, 2000) and it has been shown that dissociation can improve physical performance (Okwumabua, Meyers, Schleser & Cooke, 1983; Scott, Scott, Bedic & Dowd, 2000). Although some authors have attributed music's ergogenic qualities to dissociation, there remain some issues with this hypothesis. First, whilst dissociation has been often been advanced to explain music's performance enhancing properties, many (e.g. Anshel & Marisi, 1978; Szabo et al. 1999; Hayakawa et al., 2000) have not actually measured those variables associated with dissociation. Second, a study by Elliott (2005) revealed that although music did appear to redirect

participant's attention from the internal cues associated with exercise during the early stages of a 20-minute cycle trial, this effect diminished as the trials progressed. Despite this, there was no impact upon exercise intensity. That is, the reduced distractibility of music was not accompanied by a reduction in work rate. Because of these issues, further research should be conducted before definite conclusions could be drawn regarding music-induced dissociation and its effect on aerobic exercise.

Whilst it is possible that dissociation could account for the ergogenic responses associated with music listening, there are alternatives. Arousal has been described as being a construct that represents the intensity dimension of behaviour (Landers, 1980; Martens, Veal, & Burton (1990). As such, an increase in arousal may cause a corresponding increase in behavioural intensity. Within the context of sport and exercise, there are some theorists that have stated that listening to music can alter the arousal levels of the exercise participant (e.g. Karageroghis, Terry & Lane, 1999) and research in non-exercise settings has offered some support for music's arousal altering properties (Iwanaga & Moroki, 1999; Rickard, 2004; Husain, Thompson, & Schellenberg, 2002; Thompson, Schellenberg, & Husain, 2001). One musical component that has been implicated in this response is tempo (Holbrook & Anand, 1990), with Husain et al. (2002) suggesting that arousal and musical tempo possess a positive relationship. That is, the faster the tempo the greater the intensity of the arousal response. If this is the case it is feasible to hypothesise that 'faster' music will provide greater ergogenic benefit than music of slower tempi. Although the preceding research could implicate arousal as a mechanism through which music can enhance physical performance, direct empirical support is limited, thus further research is required to determine the relationship between music, arousal and aerobic exercise.

In summary, although there is evidence that music possesses ergogenic properties the mediators of this effect are unclear. Music has been shown to induce dissociation; a state that has been shown to enhance physical performance; so it is possible that it is this that explains music's performance enhancing properties. Alternatively, listening to music may provoke alterations in arousal; considered as the intensity dimension of behaviour; thus it is conceivable that this reaction is responsible for the ergogenic gains associated with music listening.

In the first instance, this study sought to determine whether listening to music would impact upon the rate at which aerobic exercise was performed; results would add to the extant literature on the application of music within the exercise environment. Exercise intensity was assessed via distance travelled in 20-minutes. Secondly, we also aimed to discern whether dissociation and/or arousal could be implicated in any subsequent ergogenic responses. The study required participants to perform four 20-minute cycle ergometer trials (three music conditions and a control); the music conditions being 'slow' music, 'moderately fast' music and 'fast' music. Because music liking may impact upon experimental outcomes; a dislike of the tracks utilised may nullify any potential benefit (Karageorghis & Terry, 1997; North & Hargreaves, 1997); the degree of liking for the musical selections was also monitored. Whilst it is hypothesised that listening to music will produce ergogenic gains, predicting the mediator of any such response is difficult. Specifically, it is possible that either dissociation or arousal will be implicated. Also, although there is reason to believe that tempo will impact upon arousal, we are unsure as to whether tempo will influence dissociation. It is also conceivable that degree of music liking will have a bearing on experimental outcomes. This investigation will attempt to address these uncertainties.

Method

Participants

Participants were eighteen undergraduates undertaking sport-related degrees in the north of England: 8 male (M age = 21.4 years SD = 0.6) and 10 females (M age = 20.9 years SD = 1.2). All those involved were born and raised in the UK and all verified that contemporary electronic dance music (see below) was a musical style that they enjoyed listening to. All had claimed that they had experience and preference for exercising to music. All participants indicated that they undertook regular aerobic activity performing at least one session per week that conformed to the American College of Sports Medicine's intensity/duration recommendations for aerobic exercise (ACSM, 1998).

Music Selection

It is worth noting that the current authors are aware of the work of Karageorghis et al. (1999). Karageorghis and colleagues have developed the Brunel Music Rating Inventory (BMRI) as a means of selecting musical accompaniment to exercise. Although research has supported the inventory's application, its use was nevertheless omitted from this investigation. The rationale behind this decision was thus. In the studies of Elliott et al. (2004; 2005), music was selected through the implementation of the BMRI, however, the results suggested that music may not need to be chosen in this manner to induce ergogenic responses. Given the relatively lengthy procedures required for this method of music selection, the decision was taken to appoint music on more limited criteria; the music was congruent with the preferences of the experimental participants. Based on the findings of Elliott (2004; 2005) it was assumed the variables under scrutiny (exercise intensity, RPE, affect and arousal) would be altered sufficiently to address the research aims. Therefore, all musical selections were considered to be contemporary electronic dance music. That is, the style of music used features regularly in the UK music charts and is characterized by a consistent and accentuated electronic beat (for a more detailed description see WordIQ, 2006). As stated previously, this particular genre of music was 'liked' by experimental participants. For the purpose of this investigation, music for the three experimental conditions was classified as 'slow', 'moderately fast', and 'fast'. Music for the 'slow' tempo condition was selected from a genre termed 'chill-out' dance music; all tracks possessed a tempo of approximately 100bpm. For the 'moderately fast' condition, music was selected from a genre categorized as being 'club-anthems'; all the tracks possessed a tempo of approximately 140bpm. The 'fast' tempo condition, music was selected from a genre termed 'happy-house'; all the tracks possessed a tempo of approximately 180bpm. The selected compositions were recorded onto a total of six writable compact disks, two for each music condition. Each compilation contained five tracks from the corresponding genre. It could be argued that to improve internal validity, five tracks should have been selected and their tempo manipulated to correspond to the demands of the three conditions. However, such a process would require specialist equipment, would alter the inherent characteristics of the music, and would also reduce external validity.

Measures

Exercise Intensity. As a measure of exercise intensity the distance cycled by participants in each 20-minute trial was recorded in kilometres (to the nearest metre) on the built-in cycle computer of the Monark 818E Ergometric Ergometer. Four measurements were taken during each trial (minutes 5, 10, 15, and 20). On a mechanically braked ergometer, at a given resistance any increase in pedal cadence will produce an increase in work rate (watts). Therefore, work rate (watts) for each condition was also calculated.

Rate of Perceived Exertion. Borg (1982) has suggested that for most applied studies the original 15-point RPE scale should be utilised. However, Noble and Robinson (1996) have argued that the validity of the RPE procedure can be influenced by previous rating experience. Noble and Robinson (1996) therefore suggest that prior to use, participants should be provided with a number of 'rating practice' sessions. As part of their course of study, the majority of the participants involved in this study had received training, and practice, in the use of Borg's 10-point RPE scale (Borg, 1982). Therefore, this measure was adopted in the belief that it would improve the accuracy of the values obtained. The 10-point RPE consists of perceived workloads ranging on a semantic continuum from 'nothing at all' to 'maximal'. Watt and Grove (1993) have indicated that the 10-point scale is a valid measure of perceived exertion. Four measurements were taken during each trial (minutes 5, 10, 15, and 19). Upon completion of each trial, a mean RPE score was calculated.

Affect. The Feeling Scale developed by Rejeski (1985) was applied to monitor assess in-task affect. The 11-point scale ranges from +5 (feeling very good) to -5 (feeling very bad) with semantic anchors at 2-point intervals. Four measurements were taken during each trial (minutes 5, 10, 15, and 19). Upon completion of each trial, mean affect scores were calculated. The scale has been found to be a valid and reliable measure of affective states during exercise performance (Hardy & Rejeski, 1989).

Arousal. This was assessed through the use of the excitedness scale (Rushall, 1979). The 10-point scale consists of the following semantic anchors -10 (bored, sleepy, very relaxed) through to +10 (extremely excited, wild, raging mad). Four measurements were taken during each trial (minutes 5, 10, 15, and 19). There appears to be no data regarding the validity of this scale, but Rushall (1979) proposes that it does measure arousal and the scale does possess face validity. It is worth stating that alternative measures were available. For example, Thompson et al. (2001) employed the vigour and depression components of POMS. However, this study was concerned with the distracting qualities of music and as such it was felt that the application of multiple-item measures such as POMS would interfere with the auditory stimulus, hence the application of the single item excitedness scale. Addressing the absence of physiological measures of arousal, in the exercising participant simple measures such as heart rate may not be appropriate in this instance. Specifically, at moderate to high intensities heart rate is more indicative of exercise intensity than emotional state; at low intensities heart rate is influenced by factors such as arousal (Janz, 2002). As such, it was felt that a psychological measure would prove to be more informative.

Music Liking. This was assessed via the Music Liking Scale developed by North and Hargreaves (1995). The 10-point scale consists of the following semantic anchors, 1 (did not like at all) to 10 (liked very much). However, because in this study the scale was being adopted to make a concurrent assessment of music liking, the tense was amended to represent the present, e.g. 'do not like at all'. Four measurements were taken during each trial these being timed to ensure that no one track was rated twice (minutes 3, 8, 13, and 18). There is no data regarding the validity of this scale, however,

there is existence of face validity and the scale has been successfully employed by North and Hargreaves (1995).

Equipment

Participants performed all trials on a Monark 818E Ergomedic cycle ergometer. Music was played through one of two JVC RC-EX10 compact disc players and participants were required to wear Panasonic RPHV297, in-ear headphones during each trial. Heart rate was recorded via a Polar M32 heart rate monitor.

Pre-test procedure

After consulting the School of Outdoor Studies and Sport ethical representative, ethical approval was provided, after which the following procedure was undertaken. Prior to the experimental trials participants were asked to attend a pre-test session. The session was used to determine a relative cycle resistance for each experimental participant. This required the completion of a 12-minute cycle task that was performed at a constant cadence of 50 revolutions per minute. For the first four minutes participants cycled at 50W. This was increased to 100W between minutes four and eight and 150W for the final four minutes. At the end of each workload, heart rate was recorded via a polar heart rate monitor. Heart rate data enabled predicted maximal aerobic power to be determined, whereupon 30% max was calculated for each participant. This data allowed the resistance at which experimental conditions were to be performed to be obtained. All the participants agreed that the resistance was appropriate for the task. Using the age-predicted formula, maximum heart rate was also recorded, after which 85%max was calculated. These details were noted, as was the seat height at which the cycle ergometer task was performed. Upon completion of the aforementioned procedure, participants were granted a rest period after which the various self-report inventories were introduced and explained. After the pre-test procedure had been completed informed consent documents were signed and participants were asked to refrain from eating, or drinking caffeine-based products three hours prior to testing.

Experimental trials

The experimental procedure consisted of four 20-minute, sub-maximal cycle ergometer trials. The four conditions were 'no-music', 'slow', 'moderately fast', and 'fast'. To reduce order effects, trials were counter-balanced, each participant being allocated one of twenty possible counter-balanced arrangements. In conference with the participants, attendance times were allocated; these were maintained throughout. A one-week interval separated each trial. For each music condition, volume was standardized to level of 70% of maximum. This level was loud enough to prevent external noise from being heard; none of the participants indicated that this was uncomfortably loud. For the no music condition a blank tape was played, volume was set at 100%. The aim of this was to reduce the impact of any external noise, for example, the noise created by the movement of the ergometer flywheel. To prevent personal goal setting, the electronic display of the cycle ergometer was covered

so that there was no objective indication of distance travelled; this information was withheld from participants until completion of all four conditions. Prior to testing, participants were directed to a cycle ergometer and the seat height was adjusted to the correct level. All those involved were required to perform a 3-minute warm up. The warm-up was performed at a cadence of 50rpm, with resistance of half of the predetermined load. Following this, the correct load was added to the cradle of the cycle ergometer. Participants were informed that when cycling they were to work at any intensity that they deemed to be comfortable and were allowed to vary intensity during the trials. Depending on the experimental condition, the appropriate CD, or tape for the no music condition, was placed into the music system and headphones were applied. Each CD contained five musical tracks. Once the participants were ready, the instruction to begin was given, the music was started and the trial began. During each condition measures of 'liking', excitedness, and distance were recorded. Although not a dependent measure, heart rate was also recorded. This was to ensure that all participants were performing below 85%HRmax, a threshold generally accepted as being the upper limit for aerobic exercise (ACSM, 1998). During the trials, none of the participants involved exceeded this parameter. Completion of each trial was followed by a one-minute cool down.

Data analysis

Descriptive statistics were calculated for all dependent variables. Differences between those conditions in which the data were normally distributed were assessed using repeated-measures ANOVAs. Post hoc comparisons were made using the Sidak adjustment for multiple comparisons. For data that did not exhibit a normal distribution Friedman's ANOVA was applied. In this instance, post hoc comparisons were made using Wilcoxon Signed Rank Test. Effect sizes were calculated using Cohen's *d*.

Results

Screening

Prior to statistical analysis the data was screened for normality. Z-scores were calculated to assess distribution (Field, 2005). It was found that the data for distance travelled, affect and RPE met the assumptions of normality. However, the arousal data did not and as such, this data was analysed through the use non-parametric techniques.

Descriptive statistics

Descriptive statistics across the four conditions (no music, 'slow' music, 'moderately fast' music and 'fast' music) are displayed in Table 1. These descriptive statistics show means and standard deviations for distance travelled (km), RPE, affect, excitedness and music liking.

Table 1.

Means and standard deviations for distance traveled, in-task affect, RPE, excitedness and music liking.

condition	Distance (km)	Affect	RPE	Excitedness	Music liking
No music	7.62 ±1.45	0.7 ±1.36	2.91 ±0.87	-1.3 ±4.00	-
'Slow' music	7.82 ±1.47	1.31 ±0.96	2.81 ±0.92	1.1 ±1.91	5.8 ±1.12
'Moderately fast' music	8.56 ±1.33	1.71 ±1.48	3.52 ±0.61	1.9 ±1.78	7.1 ±1.37
'Fast' music	8.44 ±1.36	1.37 ±1.78	3.09 ±0.83	1.3 ±1.98	5.5 ±2.25

Distance travelled. Total distance travelled over 20 minutes was analysed with condition as a within-participants factor. The sphericity assumption was satisfied, so no statistical correction was applied. The main effect for conditions was significant, $F(3, 51) = 7.42, p < .01$. For the condition main effect, post-hoc comparisons were conducted using the Sidak adjustment for multiple comparisons. Comparisons revealed that participants in the 'fast' music condition ($M = 8.44 \text{ km}, \pm 1.36$), compared to no music ($M = 7.62 \text{ km}, \pm 1.35$) and 'slow' music ($M = 7.82 \text{ km}, \pm 1.47$), had travelled significantly further ($p < .05$). A moderate effect size was evident between the 'fast' and no music conditions ($d = 0.6$) and a small-moderate effect was evident between the 'fast' and 'slow' conditions ($d = 0.45$). In addition, participants also travelled significantly farther in the 'moderately fast' music condition ($M = 8.56 \text{ km}, \pm 1.33$) compared to no music and 'slow' music conditions ($p < .05$). Effect sizes were moderate-large ($d = 0.68$) between the 'moderately fast' and no music and moderate ($d = 0.5$) between the 'moderately fast' and 'slow' music conditions. No significant differences were identified between the 'fast' and 'moderately fast' music conditions.

Work rate. It was the intention of the investigators to assess work-rate (watts). However, upon completion of the trials it became evident that this data was not a valid representation of cycle cadence; it was apparent that many participants had reduced their pedal cadence as this data was collected. This lack of within-trial data prevented statistical analysis. Instead, mean work rate was calculated for each experimental condition. For each music type average work rate was, no music (111 watts), 'slow' music (113 watts), 'moderately fast' (125 watts) and 'fast' (123 watts).

Rate of perceived Exertion. To assess main effects for each condition mean RPE was analysed as a within-participant factor. The sphericity assumption was satisfied, so no statistical correction was applied. The main effect for conditions was significant, $F(3, 51) = 5.42, p < .01$. Specifically, when compared to the no music condition and the 'slow' music condition, RPE was significantly higher in 'moderately fast' music condition ($p < .05$)' effect sizes were large ($d = 0.7$ and $d = 0.77$ respectively). Although RPE in the 'fast' music condition was also higher than in the no and 'slow' music conditions, this difference was not deemed statistically significant. Time * Condition interactions were also assessed for RPE; no interactions were evident.

Affect. Participants' levels of in-task affect were analysed as a within-participant factor. The sphericity assumption was not met, so the Huynh-Feldt correction was applied. The main effect for conditions was insignificant, $F(3, 51) = 2.52, p = .097$. Although significant at the $p = 0.1$ level, this result nevertheless indicates that there was no statistical difference between the mean values in any of the conditions at the $p = 0.5$ level.

Arousal. The Friedman ANOVA revealed significant differences for arousal ratings ($X^2(3) = 12.4, p < .01$). Wilcoxon tests were used to follow up this finding. A Bonferroni correction was applied so effects were reported at the $p=0.008$ level. Comparisons revealed that participants had higher excitedness levels in the 'slow' music condition ($M = 1.11, \pm 1.91$) compared to the no music ($M = 1.35, \pm 4.00, p < 0.008$) condition (moderate effect size, $d=0.61$). Although excitedness ratings were higher in the 'moderately fast' ($M = 1.98 \pm 3.05$) and the 'fast' ($M = 1.29 \pm 3.45$) music, when compared to the control condition these differences were not considered statistically significant.

Music liking. Mean values for each music condition were above the median value of five. This indicates that the music was received positively. Music liking ratings were analyzed with condition ('slow' music, 'moderately fast' music and 'fast' music) as a within-participants factor. The sphericity assumption was satisfied, so no statistical correction was applied. The main effect for conditions was significant $F(2, 34) = 7.22, p < .01, \eta^2 = .30$. For the condition main effect, post-hoc comparisons were conducted using the Sidak adjustment for multiple comparisons. Comparisons revealed that participants showed greater liking for the 'moderately fast' music condition ($M = 7.19, \pm 1.37$) compared to both the 'slow' music ($M = 5.88, \pm 1.12, p < .05$) and 'fast' music ($M = 5.59, \pm 2.25, p < .05$) conditions. Effect sizes were large ($d= 1.06$ and $d=0.9$ respectively). No significant difference in music liking was identified between the 'fast' and 'slow' music conditions.

Discussion

This investigation had a number of aims, the first of which was to examine whether listening to music would have any impact upon the rate at which participants performed an aerobic cycle ergometer task. Results revealed that both 'moderately fast' and 'fast' music did elicit significant increases in distance travelled when compared to 'slow' music and the control conditions. However, there was no significant difference between the 'moderately fast' and the 'fast' music conditions. It was also found that when compared to the control condition 'slow' music had no significant impact on sub-maximal work rate. These results do appear to implicate musical tempo in the exercise intensity response. However, that there was no difference between the 'moderately fast' and the 'fast' conditions indicates that once above a particular tempo threshold (≈ 140 bpm), this relationship terminates.

Addressing causality, the tempo-intensity hypothesis was based upon the assumption that the speed of music would alter arousal levels and this in turn would influence the rate at which exercise was performed. This does not appear to be the case, as when compared to the control, all music types led to a slight increase in arousal. Although arousal levels were similar in all the music conditions, it was only in the 'slow' music condition that this elevation was deemed to be statistically significant. Hence, despite some minor increases in arousal, there was no evidence of any relationship between tempo and arousal. That arousal levels were similar across all music conditions suggests that arousal cannot be advanced to explain the increases in exercise intensity observed in the 'moderately fast' and 'fast' music conditions. It is of course possible that musical tempo has no impact on arousal, however, it should be noted that from conversations with some of the participants, comments were passed regarding the upper anchors ('Wild' and 'Raging mad') of the excitedness scale. For some at least, these terms were considered to be amusing, thus it is conceivable that this interpretation may have induced a ceiling effect in some of the arousal ratings. We recognise that inferences based

upon conversations with participants cannot be advanced as 'scientific' explanation; nevertheless, investigators should perhaps consider the use of alternative measures of arousal to assess this response.

Regarding dissociation, it is suggested that directing focus to external cues such as music may distract an individual from discomfort often associated with exercise (Rejeski, 1985). In the dissociative state an individual is likely to report a reduction in RPE and improved affect (Rejeski, 1985), a response that may ultimately produce ergogenic gain (Okwumabua et al., and Scott et al., 2000). Based on the findings of Elliott et al. (2005), the current authors offered an alternative to the tempo-arousal hypothesis; this being that listening to music would induce dissociation. It was assumed, particularly if the music received a positive appraisal, that there would little difference in the physical responses to music whilst in this state. The data revealed that there was some evidence of dissociation. In the 'fast' music condition RPE ratings were comparable to those expressed in the control and 'slow' music conditions. This was despite an increase in exercise intensity in this condition. Hence, listening to 'fast' music does appear to manipulate effort sense. However, although RPE was only slightly elevated in the 'moderately fast' music condition, this increase was deemed to be statistically significant. As such, it appears that when performing exercise to 'moderately fast' music, participants were more aware of the internal cues that represent exertion level. In a previous investigation by Elliott et al. (2005) measures of RPE revealed a time interaction, that is, in both of the music conditions, there was a significant increase in RPE as the experimental trials progressed. No such interactions were evident in the current study.

Affect has also been advanced as an indicator of dissociation. In-task affective responses revealed that this was similar in all of the conditions. Therefore, the increase in work rate in the 'moderately fast' and 'fast' conditions, and the elevated RPE reported in the 'moderately fast' condition was not detrimental to the participant's affective state. Again, this could be interpreted as evidence for dissociation.

The data concerning RPE and affect does hint towards the occurrence of dissociation. For example, in the 'fast' condition there were significant increases in distance travelled, yet this did not impact upon effort sense or affective responses. However, the strength of this hypothesis is weakened by the fact that the increases in work rate in the 'moderately fast' condition, although having no impact upon in-task affect, did appear to have been registered by the participants. Nevertheless, given that the elevation in RPE that was observed in the 'moderately fast' condition was practically small (< 1 RPE unit) the authors suggest dissociation can be implicated as a mediator of work-rate. This assumption is supported by the fact that in the 'slow' music condition, where there was no evidence of dissociation, there was no increase in distance travelled. It is unclear why 'slow' music failed to divert participants' attention. There have been suggestions that it is characteristics such as lyrics, melody and harmony that serve to direct attention away from internal cues (Crust & Clough, 2006). Although the music in the 'slow' condition did contain these elements, it is possible that these components were more influential in the faster selections, thus aiding dissociation. Alternatively, had the music in the 'slow' condition been perceived negatively, then this could have accounted for the responses to 'slow' music as it has been suggested that a dislike of a particular musical composition, or genre, may negate any potential benefit (Karageorghis & Terry, 1997; North & Hargreaves, 1997). However, the results revealed that none of the music types received a negative evaluation. Addressing this issue, although it is likely that a dislike of the music utilised would have

impacted upon the experimental outcomes, in this instance, a positive appraisal, regardless of its strength, was sufficient to induce the observed changes. For example, despite the 'moderately fast' music receiving the highest liking rating, this had a similar effect upon work-rate as the 'fast' music. Similarly, the 'slow' music received a similar 'liking' rating to the 'fast' music, yet ergogenic responses were only evident in the latter. Also, despite some differences in 'liking', all three music types led to similar increases in arousal. Summarizing the findings, the authors acknowledge that the results of this investigation are somewhat ambiguous. It was found that both 'moderately fast' and 'fast' music provoked significant increases in distance travelled. Although there are some problems with attributing this response to dissociation, from the available data this appears to be the most likely explanation. It is unclear why tempo appeared to influence this response. There was no evidence to suggest that arousal impacted upon work rate. It is worth stating that it is possible that another factor provoked the increases in distance travelled. A number of researchers have claimed that musical tempo can act as a movement regulator (Karageorghis et al., 1999; Hohler, 1989, Gfeller, 1988), thus it is possible that participants utilized music in this manner and synchronized pedal cadence to musical tempo. Although data regarding pedal cadence was recorded, because of validity concerns this was not utilized. Future research should consider the impact of synchronization on physical responses to music.

Whilst there remains some ambiguity regarding the mechanisms responsible for the increases in exercise intensity, these findings nevertheless have practical implications. Specifically, music received positively, with a tempo of 140 bpm or 180 bpm can provoke an increase in exercise intensity; this finding may have implications for those involved in cardio-respiratory exercise programs. Furthermore, it has been argued that positive affective responses during exercise can increase the likelihood of the behaviour being repeated (Godin, 1994). The fact that the increases in exercise intensity observed in this study were not necessarily accompanied by negative affective reactions may have implications for exercise adherence. Furthermore, 'slow' music, whilst not providing ergogenic gain, does not appear to have a detrimental effect upon the exercise participant and therefore can be played in the exercise environment without provoking a negative response. It should be noted that the results of this investigation do not necessarily mean these results will be transferable to other music genres as it is possible that there are characteristics specific to contemporary electronic dance music that are particularly advantageous to the exercise participant. Hence, further investigation is required to examine the impact on other musical idioms on psychophysical responses during sub-maximal exercise.

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