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A Comparison of the Effects of Acoustic and Electronic Musical Instrumentation on 2km Maximal-Intensity Cycling

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ABSTRACT

Objective: To investigate the influence of electronic and acoustic instrumentation on cycling performance, namely speed, power, cadence, heart rate (HR) and rating of perceived exertion (RPE). Due to its strong beat and ubiquity in gymnasia and sports-related media, the hypothesis was that *Electronic* music would yield the best performance, followed by *Acoustic* music and finally *No Music*. ***Method****:* 10 university-level ball-sport athletes completed a 2km cycling trial in three conditions - *Acoustic* music (A), *Electronic* music (E) and *No Music*, the control (NM). RPE was measured at 1km and 2km, and average HR was measured throughout. All other variables were recorded on the cycle ergometer. The music chosen was an electronic and an acoustic version of '*One Last Time*' by Ariana Grande. ***Results****: Acoustic* music yielded the fastest times, the highest average power and the highest average cadence. *Electronic* music produced the lowest RPE values. *No Music* produced the highest power peak and cadence peak. ***Conclusion****:* The 'best' condition for cycling was *Acoustic* music, and the *Electronic* and *No Music* conditions proved to be the 'worst' conditions. Several outliers, the small number of participants and the lack of significant results all imply the need for further research in this area.

1. INTRODUCTION AND LITERATURE REVIEW

Many people choose to listen to music whilst exercising, and the scholarship field around this area is substantial. According to Costas Karageorghis (2017), there are three ways of using music to improve sporting performance: 'pre-task', 'synchronous' and 'asynchronous' (2017:15). 'Pre-task' indicates listening to music before exercise, to 'arouse, relax, or regulate the mood of an individual or a team' (Ibid.). 'Synchronous' and 'asynchronous' refer to whether or not the music's rhythm and tempo are in pattern with the movement of the exerciser. Synchronous music acts as a sort of metronome, whilst asynchronous music implies the evasion of 'conscious synchronization', rendering music simply a motivator and a distractor (Ibid.). This study was conducted using asynchronous music.

Music's Effects. The effects that music can have on the exerciser can broadly be categorised into three sections: psychological, psychophysical and ergogenic. Psychological effects are in reference to 'mood, emotion, affect (feelings of pleasure or displeasure), cognition (thought processes), and behavior' (Karageorghis, 2017: 14). Psychophysical effects are 'how the brain interacts with the physical world' (Ibid., 15), the most common example of which is the perception of physical exertion. Ergogenic effects are effects on athletic performance, such as 'endurance, power, productivity, or strength' (Ibid., 15), usually achieved by improving work capacity or by reducing fatigue.

Psychological Effects. Studies into psychological effects have shown that listening to music whilst exercising can positively influence mood, emotion and cognition. Brownley et al. (1995) conducted a treadmill study with trained and untrained runners completing low, moderate and high intensity exercise. Results concluded that there was no difference overall between training groups with regards to affect (pleasure), however untrained participants had a more positive affect whilst listening to fast music, during both low and high intensity exercise, in comparison to their trained subject counterparts. The authors concluded that it may be beneficial for untrained runners to listen to fast, upbeat music, although it would be counterproductive, and thus not recommended, for trained runners.

Another relevant study is by Moss, Enright and Cushman (2018) which investigated 'psychological, psychophysical and psychophysiological responses during power-based and strength-based exercises' (Moss, Enright and Cushman, 2018: 128). Participants completed squat and bench exercises whilst listening to no music, electronic dance music, metal and self-selected music. RPE was similar for the no music, metal and self-selected music conditions; however it was higher for EDM. All music conditions increased positive mood.

Drylund and Wininger's study (2008) furthered this body of research by focusing specifically on how music preference and exercise intensity have a psychological influence. 'When participants paid attention to the music, music accounted for roughly 5% of the variance in exercise enjoyment' (Drylund and Wininger, 2008: 114). With regards to attentional focus, the high intensity condition resulted in the greatest association, with the most preferred condition having the greatest dissociation.

The aforementioned studies have several shortcomings. Brownley et al.'s (1995) results risk being undermined by contending, previously conclusive, research, namely studies by Bean and Edwards (1985), Fowler et al. (1987), and Frankena and Vaught (1986). This may be due to the variant exercise method: Brownley et al. (1995) used a treadmill, rather than a cycle ergometer. Moss, Enright and Cushman's (2018) results could have been skewed by fatigue. Dryland and Wininger (2008) noted the limited selection of music in their study, explaining that the preference choice of the participant may not have been their absolute preferred choice.

Psychophysical Effects. Psychophysical effects largely refer to ratings of perceived exertion, a topic central to much of the scholarship field. Szmedra and Bacharach (1998) carried out a test on ten well-trained men, who completed two treadmill exercises: one with music and one without. RPE was taken at three-minute intervals, and the results concluded that RPE was lower during the music condition than the non-music condition. This might have been because the music (a popular medley of classical music) was relaxing, thus reducing muscle tension and making the exercise feel easier. Yamashita et al.'s test in 2006 comprised 30min seated rest (control), 30min submaximal cycling, 35min recovery period, each at 60% and 40% VO2 max. RPE did not change during 60% VO2 max, however at 40% VO2 max, the recorded RPE was lower with music than without.

Potteiger, Schroeder and Goff (2000) carried out a cycling test, whereby 27 participants performed 20 minutes of moderate-intensity exercise four times, at a power output of 70% VO2 peak. The conditions were fast upbeat music, classical music, self-selected music and no music. It transpired that the central, peripheral and overall RPE values were lower for each music condition in comparison to the no music condition. The researchers therefore concluded that music in this instance acted as a distractor.

Stork et al.'s (2014) test explored the prevalence of perceived exertion and perceived enjoyment in sprint interval exercise. They deduced that there was no difference in RPE between music and no-music conditions. Contrastingly, perceived *enjoyment* increased over time and was constantly higher with the music condition.

Though these studies suffer an expected array of limitations, they each contribute novel conclusions to the scholarship field and thus, must be lauded. For instance, the research undertaken by Stork et al. (2014) was the 'first study to include psychological measures before, during, and after SIT' (2014: 1059). However, in future research, the synchronicity and motivational quality of music could be altered, as well as incorporating a larger focus on participant music preference.

Ergogenic Effects. The third and final type of musical effect on exercise is ergogenic. This effect occurs when listening to music ameliorates sporting performance, through means of 'delaying fatigue or increasing work capacity', most commonly achieved by improving 'endurance, power, productivity, or strength' (Karageorghis, 2017: 15). The key elements for producing these ergogenic effects are largely tempo, lyrics and rhythm.

Waterhouse, Hudson and Edwards (2009) tested the effects of tempo on cycling using six popular music tracks of varying tempi. Participants cycled at self-selected work-rates and listened to each song thrice, once at normal tempo, once +10% and once -10%, unbeknownst to the participants. Contrastingly, Potteiger, Schroeder and Goff (2000) used the conditions 'fast upbeat music, classical music, self-selected music, and no music' (2000: 848). In Yamashita et al.'s (2006) study, the participants were asked to choose their favourite music, which turned out to be all pop music tracks, ranging from 92 to 162bpm. Jarraya et al. (2012) used music between 120 and 140 bpm in the warm-up of their study, after which participants had to undertake a 30s Wingate test.

Waterhouse, Hudson and Edwards' (2009) study supported the idea that faster music ameliorates sporting performance. Faster music increased distance covered/ time, power, cadence, HR and RPE, all of which were lower with slower music. Jarraya et al.'s (2012) study concluded that HR, RPE and fatigue were not affected by the addition or exclusion of music in the warm up. However, power output significantly increased after listening to (high tempo) music during the warm up. In Potteiger, Schroeder and Goff's (2000) study, the no music condition yielded the highest RPE results, compared to all the music conditions.

Potteiger, Schroeder and Goff's (2000) study and Yamashita et al.'s (2006) study are both critiqued for the use of a 'self-selected' category, due to its vagueness and variety of tempo. In the former study, there was also no music with moderate bpm; it was either slow tempo (classical) or fast-tempo (jazz).

The studies by Yamashita et al. (2006), and Waterhouse, Hudson and Edwards (2010) show strong results, which are largely compatible with copious previous studies, such as Szabo et al., (1999), Potteiger et al. (2000), which all claim music to act as a 'distractor', and studies such as Karageorghis et al. (1999), Macone et al. (2006) and Simpson & Karageorghis et al. (2006), all focusing on the role of music as a 'motivator'. However, both studies could improve the validity of their results by increasing and diversifying their sample size, or by investigating other forms of exercise.

Indeed, the prevalent gendered sample design is often regarded as jeopardising the validity of results within the field. Waterhouse et al. (2010) admitted to their study being somewhat narrow, as their results do not necessarily apply to 'females, to other age groups and modes of exercise' (2010: 68). Despite the study by Jarraya et al. (2012) supporting much previous research, it was not conducive to the findings of Pujol and Langenfield (1999) and Yamamoto et al. (2003), who concluded that listening to music during the warm-up had no effect on the Wingate test. It can be assumed that contradictions with some of the other studies would have been as a result of the gender difference.

In their study, Potteiger, Schroeder and Goff (2000) mentioned the following findings: Copeland and Franks (1991) showed that slow music produced lower RPE results during submaximal exercise, but increased time to exhaustion, whereas Kibler and Rider (1983) found that sedative music reduced anxiety and fast music increased physiological arousal and state anxiety. In general, however, music has been found to have a decreasing, and therefore positive effect on RPE in exercisers.

Sanchez et al. (2013) investigated the role of lyrics in their study. The participants performed three 6-minute cycling exercises at 75% of their maximum heart rate, with music conditions as follows: music with lyrics, same music without lyrics, no music control. The results concluded that cadence increased during both music conditions, whilst RPE and HR remained constant.

The study has several shortcomings. Firstly, fatigue could have reduced engagement with the lyrics. Secondly, as the first experiment to investigate lyrics' impact on exercise, there poses an issue of lack of corroborating research. Additionally, due to the limited music choice (8 songs), the researchers might have benefited from including self-selected music, which Razon et al. (2009) suggested might improve sporting performance. Lastly, as the songs were well-known, the participants may have been imagining the lyrics in their head during the music-without-lyrics (NL) condition. Equally, the lyrics' meaning and interpretation were not taken into consideration during this study.

Having explored the effects of music, and aware of the lesser-researched area of instrumentation, the current study sought to address gaps within the existing research. Tempo, volume and song choice were treated as constants in this study, rendering instrumentation the only varying factor. Since there is not much research in this area, the hypotheses were somewhat speculative. However, due to most people's preference, and the fact that electronic music has a strong beat (good for entrainment and synchronisation, and therefore included in workout playlists and played in gymnasia), it was hypothesised that *Electronic* music would yield the strongest sporting results, followed by *Acoustic* music, and then *No Music*.

2. METHOD

Subjects. Twelve male volunteers, aged 19-22 originally participated in this study however, due to illness and injury, only ten completed all three testing days. The 10 subjects had a mean age of 21.1 ± .86, a mean weight of 79.78 ± 7.74 and a mean height of 180.9 ± 10.28. The test only comprised males, in order that the participants might be fairly compared. All subjects were Durham University students and university-level ball-sport athletes. Of the 10 participants, four played rugby, four played hockey and two played cricket.

Before testing, each participant took their anthropometric readings from a bioelectrical impedance machine (Accuniq BC720, Daejeong, Republic of Korea). This gave them data such as a reading of their body type, body mass index, muscle mass percentage in each limb, and percentage of body fat.

The mean BMI (body mass index) for the subjects was 24.42kg/m² ± 2.14 and the mean PBF (percentage of body fat) was 19.56% ± 3.15. It is claimed that 'for most adults 18.5 to 24.9 is the healthy range' ('BMI and Obesity" 2019). According to a calculator and a scale provided by the BBC, the average BMI reading of the participants landed at the upper end of the 'healthy category'. (N.B. the scale reads underweight - healthy - overweight - obese - very obese) (Ibid.).

Study Design. The design of this experiment was approved by Durham University Ethics Committee and the testing took place in the Durham University Physiology Laboratory. It used a repeated-measures experimental design, with the independent variable being music condition and the dependent variables being speed, power, cadence, heart rate and rating of perceived exertion.

Procedure. The participants were required to come to the laboratory four times in total: once for a familiarisation day and three times for testing (Monday-Friday-Monday). During the familiarisation day, participants signed the consent form and filled out a pre-testing questionnaire, before they practised cycling on the Wattbike cycle ergometer to familiarise themselves with the equipment. This meant finding the right saddle height, and getting used to cycling with the resistance set to 5 - chosen as medium intensity (the resistance ran from 1-10). On the familiarisation day, the testing procedure was explained to the participants. They were advised to eat the same type of food in the 24 hours prior to testing days, and also to refrain from drinking caffeine on the testing days. The participants cycled at the same time on each of the days, and the testing ran from 11.00 to c. 17.00.

Participants were required to cycle 2km at maximal intensity, with a different music condition - either *Acoustic*, *Electronic* or *No Music* - each day. It was not specified whether the participant should pay extra attention to the music. Instead, they were asked to cycle as they normally would, at maximal intensity.

On the first day of testing, after having their weight measured, the participants took up to ten minutes to warm up. This time was then replicated for the other warm-ups. No music was played during the warm-up and there was no set specification as to a warm-up procedure; it was up to the discretion of the participants. They were then given Apple Airpods to wear during the cycling, with the volume set to 70 decibels. The test began the moment the subject started cycling, at which point the music started. After cycling, the participants cooled down as they saw fit.

The RPE scale was held out for the participants at 1km and at 2km, at which points they stated their RPE to the administrator. The remaining variables (time, speed, distance, cadence, power, heart rate) were unseen to the participants, as the screen which displayed these on the ergometer was turned away from them. This was to prevent participants trying to improve their performance, having seen their initial results. It was felt this would be more of a distraction and an incentive than the music, as the men were all competitive athletes.

Apparatus. Testing was completed on a Wattbike cycle ergometer (Wattbike Ltd, Nottingham, UK). This ergometer collected the following data: length (speed), average power, power peak, L%/R% (percentage of left and right leg power), cadence (revolutions per minute), cadence peak, and distance. Participants chose the rate of pedalling (cadence), as well as the force with which they pedalled. There was no advice given to participants to synchronise their pedalling with the beat of the music. Heart rate was measured on a Polar T31, (Polar Electro, Kempele, Finland), by an electrode monitor attached around the participant's chest. RPE was measured using the Borg 1982 6-20 RPE scale.

Music Selection. The music selected for this study was '*One Last Time*' by Ariana Grande - both the original, electronic version ("Ariana Grande - One Last Time (Lyric Video)" 2015) and an acoustic version ("Ariana Grande - One Last Time (Acoustic Version)" 2014). It was imperative that the acoustic and electronic versions were as similar as possible in every aspect other than instrumentation. With these two versions, the tempo was exactly the same (125 bpm), as was the key (Ab major), the singer (Ariana Grande), the words and the tune. The instrumentation varied: the electronic version used synthesizer, drums and voice, whereas the acoustic version just used voice and piano. The music was played via Apple Music and YouTube on the administrator's iPhone.

Being regularly played on the radio and in nightclubs, this song was chosen as one that was familiar to all participants, thus familiarity did not affect results. It was also chosen because of its major tonality, upbeat nature, and because the rising chorus line was thought to be an uplifting accompaniment to exercise. The song lasts 3 minutes and 17 seconds, therefore, no participant finished the song before they finished cycling. The tempo of *One Last Time* is 125bpm, which is within the bracket claimed by Costas Karageorghis (2017) as being the 'optimal tempo range' for asynchronous music accompanying stationary cycling: ~115 bpm - ~145 bpm (2017:101). The order of conditions was different for each of the participants, so that 'order of listening' did not affect results.

Data Analysis. Means and standard deviations were calculated for all data. Statistical analyses were then calculated using a repeated measures 3-way ANOVA for time, average power, power peak, average RPE, average cadence, cadence peak, average heart rate and heart rate peak. The ANOVA was 3-way due to the study comprising one independent variable (music condition) with three levels (*Acoustic*, *Electronic*, *No Music*). Music condition and exercise efficiency were treated as within-subject factors. Results were considered statistically significant when their probability value was less than 5% ($p<.05$). The ANOVA analyses were performed using RStudio, with all other analyses being performed using Microsoft Excel.

3. RESULTS

Subjective Measures.

Follow-up Music Enjoyment Response. After completion of this study, 90% of participants admitted that they preferred the *Electronic* music condition, with only one participant saying that they preferred the *Acoustic* music condition. With regards to pure enjoyment, and not how they believed it affected their sporting performance, most participants voted 4 out of 7 for *Acoustic* music (1 = strongly dislike, 7 = like a lot), and most participants voted for 6 out of 7 for the *Electronic* music. From this one can conclude that *Acoustic* music yielded a moderate enjoyment response, with *Electronic* music yielding a more positive enjoyment response.

Answers from Questionnaires – Music Preferences. The participants were asked to state their music preferences in the questionnaires given to them before and after the testing. It emerged that most of the participants (80%) would naturally listen to music whilst exercising: 6 would listen to electronic, 2 acoustic and 2 neither. Contrastingly, in an everyday situation, *Acoustic* music was the choice of five participants, whilst three participants voted for *Electronic*, and two for the option 'both'. Thus, it is interesting that, in this study, the *Electronic* music condition produced average to poor results with regards to speed, power and cadence. Adding to this, nine out of 10 participants preferred listening to the *Electronic* version of '*One Last Time*' during testing, with only one participant preferring the *Acoustic* version. To further confuse matters, before participants found out their results, when asked to estimate in which condition they cycled the fastest and slowest, most participants voted that they thought *Electronic* were their fastest condition. Only one participant thought his test in the *Acoustic* music condition was his fastest. In fact, six out of 10 participants thought *Acoustic* music was their slowest condition!

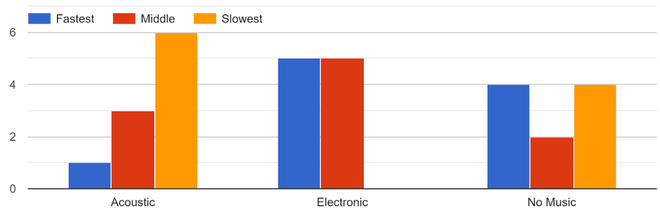

Figure 1. Estimated Ranking Order (post-exercise, pre-finding out results)

When participants were not limited to electronic or acoustic music, their music preference was varied. Responses ranged from 'pop/ charts music' to 'electronic, funk and soul' to 'hip hop'. However, it was encouraging to see that 60% of participants would naturally listen *One Last Time* in a sporting situation, as it means that the study was realistic and similar to their normal exercise.

Did Individuals Improve over the Testing Days? The order of listening was different between participants, to avoid fatigue having an effect on results. Initially, when n=12, each participant listened to the music in the same order as another participant. However, the two subjects unable to complete the testing meant that the orders *Electronic-No Music-Acoustic* and *Electronic-Acoustic-No Music* ended up only having one participant each. Fascinatingly, 4 participants got faster over the three tests, 3 got slower, and 3 had mixed results.

One explanation for the mixed results is that certain participants might have known the song '*One Last Time*' better than the others. This recognition, and indeed the possibility of connotation with previous memories or experiences, could have caused their results to be skewed, either in favour of faster results, if they were used to listening to it whilst exercising, for example, or in a detrimental manner, if it made them feel sad or lacking in energy.

Exercise Measures.

Speed. The average speed of participants did not differ hugely between the conditions, with no more than .70s between the average speed of the fastest condition (*Acoustic*) and the slowest condition (*Electronic*). However, the spread of results for the *Electronic* condition was considerably greater than those of the *Acoustic* and *No Music* conditions, which indicates that perhaps one participant's result might have swayed the results. Interestingly, the two men who did not complete the testing did do their first tests, which were both with the *Electronic* music condition. If their results were to be included, in such a way that the averages were for 10 participants for *Acoustic* music and *No Music* and for twelve participants with *Electronic* music, the outcome would have been very different. *Electronic* music would have produced the fastest results, followed by *Acoustic* music, followed by *No Music*. However, as they did not finish the testing, their times were eliminated from the results. In either case, these results did not display a statistically significant difference between conditions ($F(2,24) = .15$, $p = .86$).

There were three minor outliers (>1.5xIQR) in the speed results. In each of the conditions, the fastest time (142.49s - *Acoustic*, 143.70s - *Electronic* and 145.49s - *No Music*) was a minor outlier. As there was one for each condition, any effect that each outlier might have had was eliminated.

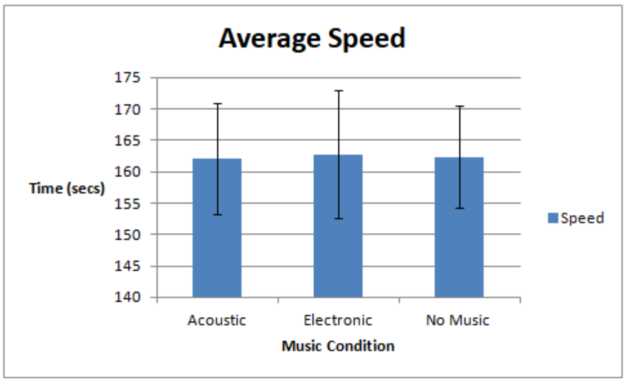

Figure 2. Average speed

Power Peak. Participants achieved their highest power peak during the *No Music* condition, followed by the *Electronic* condition, then the *Acoustic* music condition. However, the spread of values achieved with the *Acoustic* condition was the largest, and the spread for *Electronic* music was the smallest. Overall, these power peak results were not statistically significant ($F(2,24) = .12$, $p = .89$).

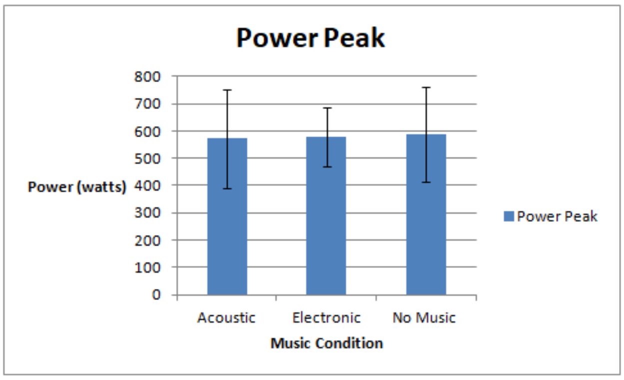

Figure 3. Power peak

Average Power. In contrast to the power peak results, the *Acoustic* music condition yielded the best results for average power. The *Electronic* condition was second, and the *No Music* condition produced the worst average power results. These results could have been down to the fact that if the participants' power peaks were the highest for *No Music*, they might have over-exerted themselves, and then proceeded to be more tired for the rest of the cycle, thus decreasing their average power. The standard deviations of these were more regular, in contrast to the power peak results, but these results were still statistically insignificant ($F(2,24) = .12$, $p = .89$).

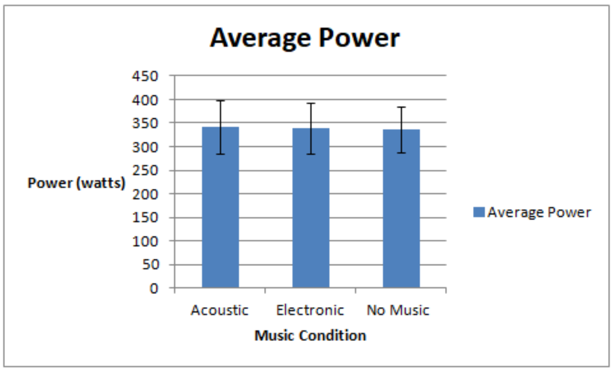

Figure 4. Average power

Rating of Perceived Exertion (RPE). Rating of perceived exertion was measured at the end of 1km and at the end of 2km using the Borg 1982 6-20 RPE scale. All RPE values were higher at the end of 2km compared to at the end of 1km. *Acoustic* and *Electronic* music reaped higher RPE values at 1km in comparison to *No Music*, however, at 2km, *No Music* produced the highest RPE values, and *Electronic* produced the lowest. On average, *Acoustic* and *No Music* conditions resulted in the highest RPE values, and *Electronic* music resulted in the lowest values. There was not much disparity between all the results and they were not statistically significant (average RPE: $F(2,24) = .77$, $p = .47$, thus $p > .05$).

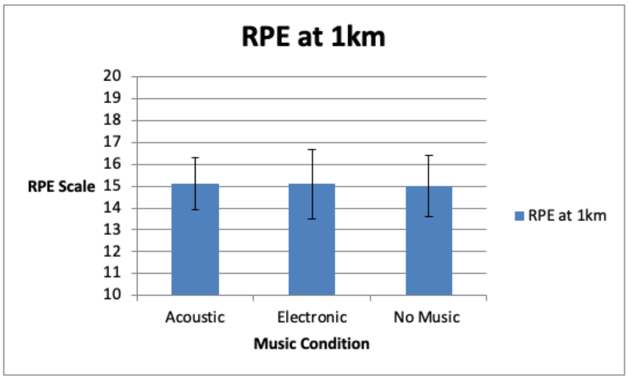

Figure 5. RPE at 1km

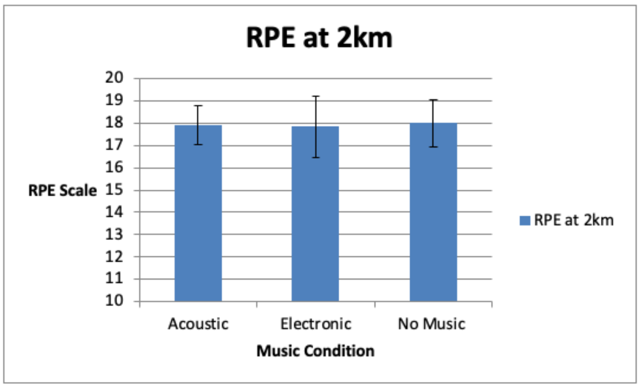

Figure 6. RPE at 2km

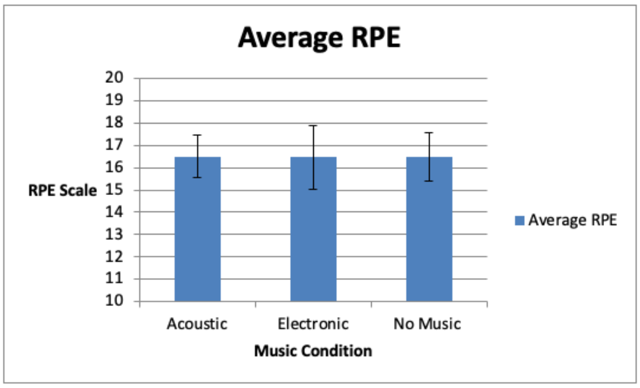

Figure 7. Average RPE

Cadence Peak. There was not much disparity between the participants' cadence (rate of pedalling), with regards to both the average cadence and the cadence peak. In terms of cadence peak, the *No Music* condition generated the most desirable results. *Acoustic* music was the next best condition, followed by *Electronic* music. *Acoustic* music produced the most widespread results, in contrast to the *Electronic* music condition, which had the smallest standard deviation value. The cadence peak data was, again, not statistically significant: $F(2,24) = .44$, $p = .65$.

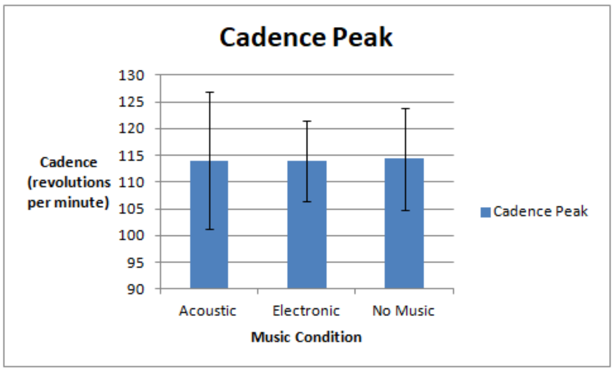

Figure 8. Cadence Peak

Average Cadence. Although the difference between the average cadence results for each condition was no more than 0.4 revolutions per minute, the *Acoustic* condition generated the highest average cadence, then the *Electronic* condition, then the *No Music* condition. The *Electronic* condition contained a wider spread of results than the other two, however. The results for average cadence were not statistically significant: $F(2,24) = .23$, $p = .80$.

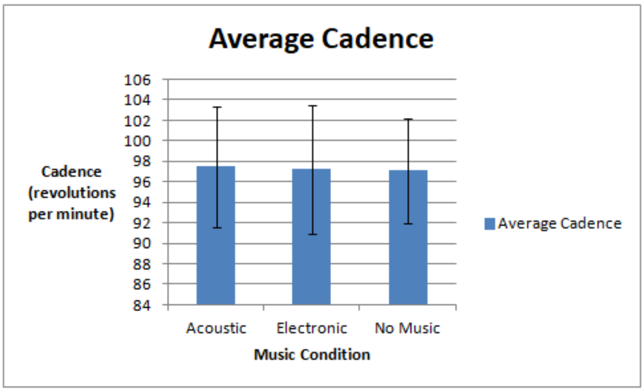

Figure 9. Average Cadence

Heart Rate (HR). A 3-way repeated measures ANOVA revealed that there was not a significant difference for participants' heart rates (both average and peak) between the three music conditions (average heart rate: $F(2,24) = .53$, $p = .60$), heart rate peak: ($F(2,24) = .24$, $p = .79$)). The participants' average heart rate was highest for *Acoustic* and lowest for *Electronic* music, whereas their peak heart rate was highest for *Electronic* music and lowest for *No Music*.

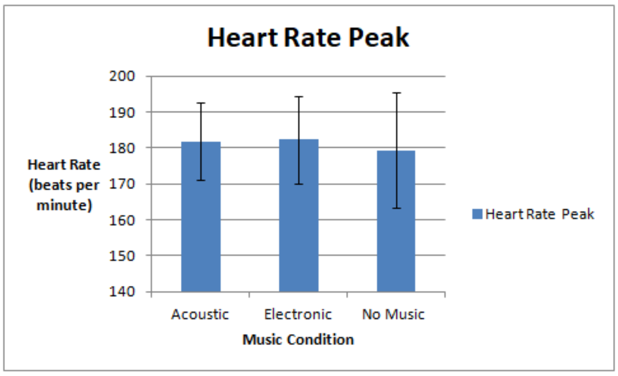

Figure 10. Heart Rate Peak

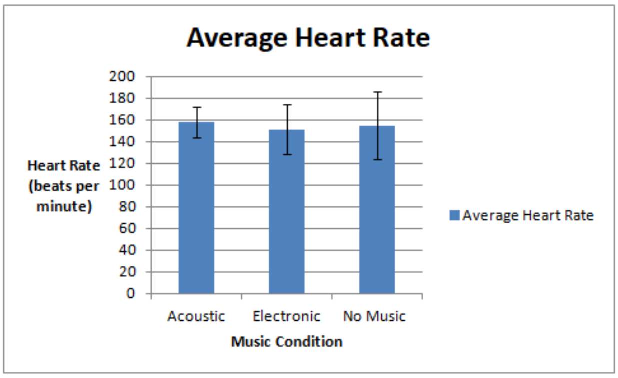

Figure 11. Average Heart Rate

4. DISCUSSION

As a pioneering study, this research has opened up an exciting avenue for future scholarship in the field of musical instrumentation's influence on sporting performance.

Speed. Contrary to the hypothesis, the *Acoustic* music condition yielded the fastest times, and the *Electronic* music condition produced the slowest times. This was unexpected, as *Electronic* music is more naturally associated with exercise, being the most prevalent kind of music on exercise playlists, e.g. on Spotify ('Workout' 2019). It was anticipated that inclusion of drums, synthesized sounds, and a more pronounced beat would enhance sporting performance, due to the motivating nature of these features. Many advertisements for sport-related products are also accompanied by electronic music, be it 'house', 'rap', 'hip-hop' or other.

Furthermore, music videos have an influencing effect, for example Ed Sheeran's 'Shape of You' music video ('Ed Sheeran - Shape Of You [Official Video]' 2017), which follows the story of two boxers. Throughout the video, they box in time with the rhythm of the song. The entire video encapsulates the ever-woven relationship between electronic music and sport.

It is of little surprise that the majority of participants thought they would cycle fastest during the *Electronic* condition. Surprisingly, however, *Electronic* proved to be the slowest condition. Perhaps this was due to the participants being trained athletes; most of their sports training is completed without listening to music, so they were not accustomed to exercising to music. Equally, with their high level of fitness, they might not have been as affected by the music condition as someone less fit. This idea is supported by Brownley et al.'s (1995) study which concluded that 'listening to fast, upbeat music during exercise may be beneficial for untrained runners but counterproductive for trained runners'. (1995: 193).

Despite controlling musical variables, other external factors such as tiredness, food consumption, hydration and temperature were unable to be controlled, but could well have had an effect on the participants. Moreover, as the speed results were not statistically significant, it is clear the test should be rerun with a larger participant number, in order to produce clearer results.

Power. Whilst *No Music* produced the best power peak results, it simultaneously yielded the worst power average results. It could be supposed, therefore, that participants might have pushed themselves too hard during the *No Music* condition, and as such, whilst having attained a high power peak, they would have exhausted themselves and subsequently cycled with less power. *Electronic* music reaped a more consistent result, being the second best condition for both average and power peak, and the *Acoustic* condition was the antithesis of the *No Music* condition. These results agree with past scholarship (e.g. Stork et al., 2014 and Waterhouse, Hudson and Edwards, 2010) that the addition of music enhances power results.

RPE. No Music was also the 'best' with regards to RPE after the first kilometre. This, again, could be because the participants were pushing themselves too early, due to not having music as a distractor. At 2km, and overall, the *Electronic* music condition produced the lowest values of perceived exertion. Perhaps the thicker texture in the *Electronic* version caused a greater distraction: the more instruments incorporated in the song, the broader the envelope of sound, suspending the participant from reality, and thus distracting them from the task at hand. This distraction in turn could have made the task feel easier, lowering their RPE. This would be interesting to explore further: how texture affects RPE.

Cadence. Cadence produced mixed results. *Acoustic* music was the best condition for average cadence, followed by *Electronic*, then *No Music*. However, *No Music* was best for cadence peak and *Electronic* music was worst. *No Music* was the best condition for average power and the worst for power peak, but it was the worst condition for average cadence and the best for cadence peak. Thus, the faster the participants pedalled the weaker force they used. As the speed results show that *Acoustic* music produced the fastest times, it could be deduced that the most speed-effective way to cycle fast is by pedalling fast, even if it means compromising on power.

Heart Rate. Heart rate differed between individuals in such a way that it is not clear which condition produced the 'best' results. Therefore, a more solid evidence base is needed in order to be able to interpret such results.

Limitations and Ideas for Future Research. There were many limitations to this experiment design, however, these have left open exciting opportunities for further research in this fast-developing scholarship field.

Firstly, the number and diversity of the participants could be expanded in order to improve validity of results. Equally, the test could be carried out on non-athletes, as the distraction/ motivation levels of music might reap greater benefits for those not used to exertion. Using athletes for the test was valuable, however it would have been beneficial to do the testing outside the hockey/ rugby/ cricket seasons so external training and tiredness could have been minimised. Additionally, completing the test more than three times would ameliorate the validity of results. On the testing days, certain aspects were beyond control. The heart rate monitors were temperamental, so a simple solution for this would be to use better quality heart rate monitors.

Many sports could be used for this test and running would be an apt substitute for cycling. Although, as a popular and well-known song, '*One Last Time*' served its purpose well, the study might have been improved had a collection of songs been used, perhaps from varying genres. A future test might also choose a song unfamiliar to participants, to eliminate the variance in familiarity between participants affecting results.

Future testing might increase the cycling distance to see what effect it might have. The 2km distance was chosen for this study because it was deemed long enough for the music to make an impact on the sporting performance, but short enough a distance for the cycling to be accompanied but just one song. (The song '*One Last Time*' lasts for 3 minutes 17 seconds; the slowest time from the participants was 3 minutes.) Balancing this was crucial, as if the cycling distance were any longer, one would either have had to change song, or repeat the song, neither of which would have been preferable.

Relevance in the Scholarship Field. The scholarship field concerning music and exercise is ever-expanding and developing, thanks to influential researchers such as Costas Karageorghis and David-Lee Priest. The idea proposed in the current study, that variance in instrumentation in exercise-accompanying music can have ergogenic, psychological and psychophysical effects, despite not being fully realised in this project, has opened exciting avenues for future research. If this study was to be rerun and significant results subsequently arose, the results would prove useful in advising people the best music to accompany exercise. Ideas for reproducing this study include expanding the participant number, testing females, and replicating the study using different sports. Furthermore, one could increase the number of testing days, whilst retaining the number of conditions, in order to reduce the chance of anomalous results, and increase validity of data. Extending the research in this field could have promising repercussions. Playlist editors could have a better idea of which music to include in their 'workout' playlists, and if artists wanted to create music for the purpose of exercising, they would know what kind of instrumentation to include in their tracks. Ultimately, this test adds a new idea to the field, one that hopefully will be taken on and explored further in the future.

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APPENDIX

This table was drawn in such a way that three points signify that the condition produced the 'best' results, two points indicate 'second best', and one point suggests that the condition produced the 'worst' results for that variable.

Table 5. Overall results

		Acoustic	*Electronic*	*No Music*
1.	Speed	3	1	2
2a.	Power Average	3	2	1
2b.	Power Peak	1	2	3
3a.	RPE 1km	2	2	3
3b.	RPE 2km	2	3	1
3c.	RPE Average	2	3	2
4a.	Cadence Average	3	2	1
4b.	Cadence Peak	2	1	3
	OVERALL	18	16	16